

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Clive P. Bosnyak, et al.
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Title: LITHIUM ION BATTERIES USING DISCRETE CARBON
NANOTUBES, METHODS FOR PRODUCTION THEREOF AND
PRODUCTS OBTAINED THEREFROM

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 8,808,909 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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EXHIBITS

- LGES-1001 U.S. Patent No. 8,808,909 (“the ’909 Patent”)
- LGES-1002 Excerpts from Prosecution History of the ’909 Patent (“the Prosecution History”)
- LGES-1003 Declaration of Dr. Yu Zhu
- LGES-1004 U.S. Patent Pub. No. 2004/0160156 (“Ohata”)
- LGES-1005 “Multi-walled carbon nanotubes functionalized by carboxylic groups: Activation of TiO₂ (anatase) and phosphate olivines (LiMnPO₄; LiFePO₄) for electrochemical Li-storage.” Ladislav Kavan et al. Journal of Power Sources 195 (2010) 5360-5369 (“Kavan”)
- LGES-1006 U.S. Patent Pub. No. 2010/0136431 (“Lee”)
- LGES-1007 U.S. Patent Pub. No. 2010/0124713 (“Farrugia”)
- LGES-1008 U.S. Patent Pub. No. 2012/0064409 (“Zhamu”)
- LGES-1009 “Chemical oxidation of multiwalled carbon nanotubes.” V. Datsyuk et al. Carbon 46 (2008) 833-840 (“Datsyuk”)
- LGES-1010 “Surface and structural characterization of multi-walled carbon nanotubes following different oxidative treatments.” Kevin A. Wepasnick, et al. Carbon 49 (2011) 24-36 (“Wepasnick”)
- LGES-1011-1013 Reserved
- LGES-1014 “Surface modified multi-walled carbon nanotubes in CNT/epoxy-

composites.” Florian H. Gojny, Jacek Nastalczyk, Zbigniew Roslaniec, Karl Schulte. Chemical Physics Letters 370 (2003) 820–824 (“Gojny”)

LGES-1015 “Sonochemical Oxidation of Multiwalled Carbon Nanotubes.” Yangchuan Xing, Liang Li, Charles C. Chusuei, and Robert V. Hull. Langmuir 2005, 21, 4185-4190 (“Xing”)

LGES-1016-1024 Reserved

LGES-1025 “The structure and property characteristics of amorphous/nanocrystalline silicon produced by ball milling.” T.D. Shen, et al. Journal of Materials Research 10 (1995), 139-149 (“Shen”)

LGES-1026 “Crystal-amorphous phase transition induced by ball-milling in silicon.” E. Gaffet, M. Harmelin. Journal of the Less Common Metals 157 (1990), 201-222 (“Gaffet”)

LGES-1027 U.S. Patent No. 9,012,073 (“Kumar”)

LGES-1028 U.S. Patent No. 9,190,694 (“Lopez”)

LGES-1029 U.S. Patent No. 7,851,085 (“Obravac”)

LGES-1030 “Labeling the Defects of Single-Walled Carbon Nanotubes Using Titanium Dioxide Nanoparticles.” Xiaohong Li, Jiali Niu, Jin Zhang, Hulin Li, and Zhongfan Liu. The Journal of Physical Chemistry B 107 (2003) 2453-2458 (“X. Li”)

LGES-1031 Excerpts from Prosecution History of EP2724403B1

LGES-1032 U.S. Patent No. 8,241,794 (“Sheem”)

- LGES-1033 “TiO₂ rutile—An alternative anode material for safe lithium-ion batteries.” M. Pfanzelt, P. Kubiak. *Journal of Power Sources* 106 (2011) 6815-6821 (“Pfanzelt”)
- LGES-1034 U.S. Patent Pub. No. 2011/0159366A1 (“Nakura”)
- LGES-1035 U.S. Patent Pub. No. 2009/0117463A1 (“Takezawa”)
- LGES-1036 Reserved
- LGES-1037 “Preparation of Nanocomposites of Metals, Metal Oxides, and Carbon Nanotubes via Self-Assembly.” Jing Li, Songbai Tang, Li Lu, and Hua Chun Zeng. *Journal of the American Chemical Society* 129 (2007) 9401-9409 (“J. Li”)
- LGES-1038 “Enhanced photocatalytic activity of mesoporous TiO₂ aggregates by embedding carbon nanotubes as electron-transfer channel.” J. Yu, T. Ma, S. Liu. *Phys. Chem. Chem. Phys.* 13 (2011) 3491–3501 (“Yu”)
- LGES-1039 “Long-time low-impact ball milling of multi-wall carbon nanotubes.” A. Kukovecz, T. Kanyo, Z. Konya, I. Kiricsi. *Carbon* 43 (2005) 994-1000. (“Kukovecz”)
- LGES-1040 “Green energy storage materials: Nanostructured TiO₂ and Sn-based anodes for lithium-ion batteries.” D. Deng, M. Kim, J. Lee, J. Cho. *Energy & Environmental Sciences* 2 (2009) 818-837 (“Deng”)
- LGES-1041 “Hydrothermal synthesis of lithium iron phosphate.” J. Chen, M. Whittingham. *Electrochemistry Communications* 8 (2006) 855-858

(“Chen”)

LGES-1042 “The preparation and electrochemical performances of LiFePO_4 -multiwalled nanotubes composite cathode materials for lithium ion batteries.” Y. Feng. *Materials Chemistry and Physics* 121 (2010) 302-307 (“Feng”)

LGES-1043 “Preparation of Single-Walled Carbon Nanotube/Silicon Composites and Their Lithium Storage Properties.” J-Y. Eom, H-S. Kwon. *Applied Materials & Interfaces* 3 (2011) 1015-1021 (“Eom”)

LGES-1044 A. Hirsch. “Functionalization of Single-Walled Carbon Nanotubes” *Angew. Chem. Int. Ed.* 2002, 41, No. 11, 1853-1859 (“Hirsch”)

LGES-1045-1049 Reserved

LGES-1050 *Molecular Rebar Design, LLC, and Black Diamond Structures, LLC v. LG Energy Solution, Ltd.*, Plaintiffs’ Disclosure of Asserted Claims and Infringement, 2:24-cv-00107-JRG

LGES-1051 Declaration of June Ann Munford (Kavan)

LGES-1052 Declaration of June Ann Munford (Wepasnick)

LGES-1053 *Molecular Rebar Design, LLC, et al. v. LG Energy Solution, Ltd.*, Sample Docket Control Order, 2:24-cv-00107-JRG

CLAIM LISTING

Limitation	Claim Language
[1pre]	A composition useful for lithium ion batteries comprising:
[1a]	discrete carbon nanotubes
[1b]	having crystals or layers of lithium ion active material attached to their surface,
[1c]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[1d]	oxidation levels from 1% to 15% by weight of the carbon nanotube.
[2]	The composition of claim 1, wherein the crystals or layers of lithium ion active material comprise tin, silicon, copper, antimony, aluminum, germanium, titanium, or mixtures thereof.
[3]	The composition of claim 1, further comprising graphene or oxygenated graphene.
[4]	The composition of claim 3, wherein the weight ratio of graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1.
[5]	The composition of claim 1, wherein the carbon nanotubes are present in a weight percentage of 0.1% to 10% by weight of the lithium ion active material.
[6a]	The composition of claim 1, comprising oxidized carbon nanotubes having crystals or layers of lithium ion active materials attached to their surface,
[6b]	wherein the carbon nanotubes are uniformly dispersed without clustering on a dimension scale less than 1 micrometer.
[7]	The composition of claim 1, comprising uniformly dispersible oxidized carbon nanotubes having crystals or layers of lithium ion active materials attached to their surface.
[8]	The composition of claim 7, wherein the crystals or layers of lithium ion active materials are chemically attached to the surface of the dispersible oxidized carbon nanotubes.

I. INTRODUCTION

LG Energy Solution, Ltd. (“Petitioner”) petitions for IPR of claims 1-8 (“Challenged Claims”) of U.S. Patent No. 8,808,909 (“the ’909 Patent”).

The ’909 Patent relates to “[c]ompositions ... useful for lithium ion batteries comprising discrete oxidized carbon nanotubes having attached to their surface lithium ion active materials.” LGES-1001, Abstract. However, such composites were well-known in the art at the time of filing of the ’909 Patent. And additional features recited in the claims—including the aspect ratio and oxidation levels of the nanotubes—were also conventional characteristics of nanotubes that are insufficient to justify validity of the claims.

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’909 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the below grounds.
LGES-1003, ¶¶1-246.

Ground	Claims	Basis for Rejection
1	1-2, 5-8	103: Ohata-Kavan
2A	1-2, 5-8	103: Lee-Wepasnick
2B	3-4	103: Lee-Wepasnick-Zhamu

Each applied reference pre-dates June 23, 2011 (“Critical Date”), which is the earliest filed application from which the ’909 Patent claims priority. Petitioner does not necessarily agree that the ’909 Patent is entitled to priority to the Critical Date,¹ but has applied references that pre-date the Critical Date and qualify as prior art, as shown below.² *See generally* LGES-1004, LGES-1005, LGES-1006, LGES-1008, LGES-1010, LGES-1051, LGES-1052.

¹ Although the ’909 Patent claims the benefit of provisional application 61/500,560, filed on June 23, 2011, this provisional does not mention, *inter alia*, the claimed aspect ratio range of “10 to 500.”

² In the May 15, 2024 infringement contentions in the co-pending district court case, Patent Owner alleges 32 alternative priority dates that the ’909 Patent may be entitled to. LGES-1050, 3-5. While such allegations do not appear to be justified—among other things because of failure to demonstrate possession of the aspect ratio and oxidation level features as claimed—Petitioner reserves the right to respond to any such similar allegations made in this IPR proceeding.

Reference	Date	Section
Ohata	8/19/2004 (published)	102(b)
Kavan	3/12/2010 (published)	102(b)
Lee	6/3/2010 (published)	102(b)
Wepasnick	8/18/2010 (published)	102(a)
Zhamu	9/10/2010 (filed) 3/15/2012 (published)	102(e)

III. SUMMARY OF THE '909 PATENT

A. Brief Description

The '909 Patent relates to “[c]ompositions ... useful for lithium ion batteries comprising discrete oxidized carbon nanotubes having attached to their surface lithium ion active materials.” LGES-1001, Abstract.

B. Prosecution History

The '909 Patent issued from a national phase entry of PCT Application No. PCT/US2012/043534. *See* LGES-1002, 79. While the claims that issued in the '909 Patent were not subject to prior art rejections by the U.S. Patent Office, the PCT application underwent international preliminary examination at the European Patent Office. *See* LGES-1002, 43-56; LGES-1031, 564. The International Preliminary Report on Patentability (IPRP; *see* LGES-1013, 542-547) stated that

“[t]aking into account later-filed evidence provided by the applicant and supporting an inventive step, it is considered not obvious to the skilled person to select carbon nanotubes with oxidation levels of 1% to 15% by weight in order to provide intimate electron transfer and enhanced mechanical strength of the active material as it is not disclosed nor suggested in the prior art nor is it common knowledge in the technical field to do so.” *Id.*, 546.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the '909 Patent as of the Critical Date (a “POSITA”) would have had at least a Master’s degree in materials science, chemistry, chemical engineering, a field relevant to polymer science and engineering, or the equivalent, and at least three years of experience in nanomaterials, electrochemistry, batteries, or polymer related activities. Additional work experience can compensate for less formal education, and vice versa. LGES-1003, ¶11.

D. Claim Construction

Based on the prior art’s description of the claimed elements being similar to that of the '909 Patent specification, no formal claim constructions are necessary in this proceeding because “claim terms need only be construed to the extent necessary to resolve the controversy.” *Wellman, Inc. v. Eastman Chem. Co.*, 642

F.3d 1355, 1361 (Fed. Cir. 2011).

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1] – CLAIMS 1-2 AND 5-8 ARE OBVIOUS OVER OHATA-KAVAN

The sections below provide an introduction to Ohata, Kavan, and their combination.³

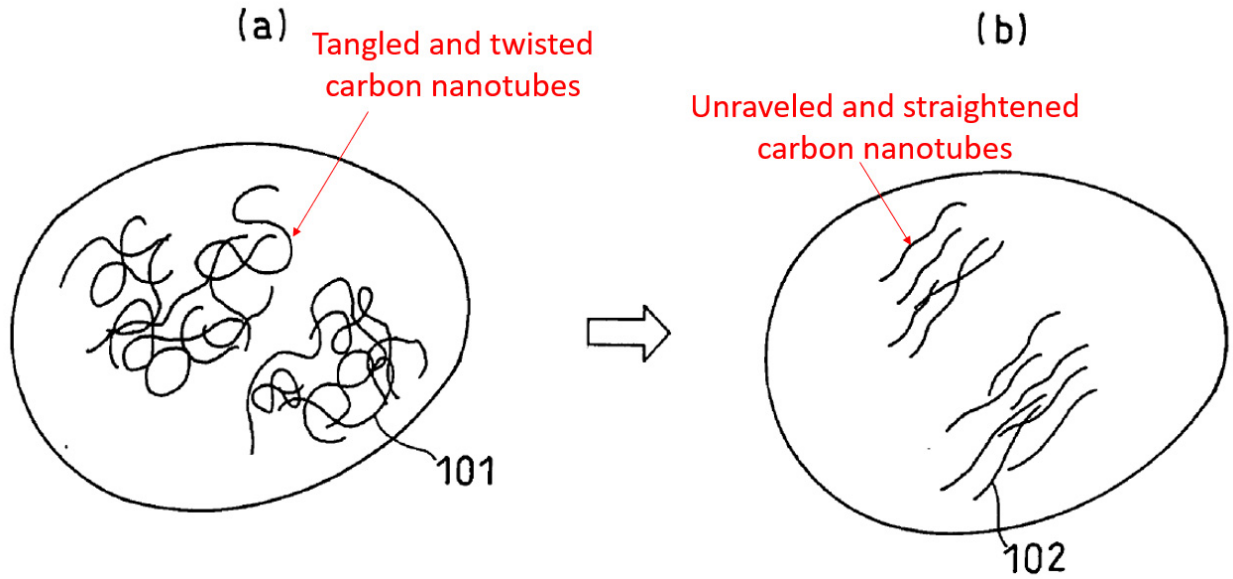
1. Ohata describes a nanotube-containing paste for lithium ion batteries

Ohata describes composites of carbon nanotubes and either positive or negative electrode active materials for use as electrodes in lithium ion batteries.

See LGES-1004, [0004]; LGES-1003, ¶19.

Ohata prepares its composites by first “producing a masterbatch by blending at least carbon nanotubes with a resin.” LGES-1004, [0015], [0022]. In this process, nanotubes that are initially “tangled and twisted with one another” (FIG. 1(a), *infra*) are “unraveled and straightened by blending them with a resin” such that they are “dispersed” in the resin (FIG. 1(b)). *Id.*, [0016]-[0017]; LGES-1003, ¶20.

³ Petitioner incorporates this discussion into Ground 1.



Ohata, FIG. 1 (annotated to demonstrate a masterbatch (b) produced by blending carbon nanotubes with a resin)

An “electrode material mixture paste” is formed by mixing “the masterbatch and an electrode active material with a dispersion medium” and is applied “onto an electrode substrate” for use in a lithium secondary battery. LGES-1004, [0023], [0025]-[0027]; LGES-1003, ¶¶21-22.

2. Kavan describes composite materials containing oxidized nanotubes for use in lithium ion batteries

Kavan describes composites of functionalized multi-walled carbon nanotubes (MWNTs) with electrode active materials, for use in lithium ion batteries. *See* LGES-1005, 1-2; LGES-1003, ¶23.

Kavan performs “oxidative functionalization” on the MWNTs to produce “MWNT-ox” (“material functionalized by oxidation with HNO₃.” LGES-1005, 4;

LGES-1003, ¶24. Oxidized nanotubes were mixed with “a powder material (TiO_2 , LiMnPO_4 or LiFePO_4),” and pastes were prepared using the resulting material.

LGES-1005, 2. The structure, composition, and electrochemical behavior of the resulting composites were characterized, showing performance advantages resulting from interactions between oxidized nanotubes and the positive or negative active material. *See* LGES-1004, 3-5, 7-9; LGES-1003, ¶¶25-32.

3. The Ohata-Kavan combination

The Ohata-Kavan combination composition uses Ohata as a starting point. LGES-1003, ¶33. An “electrode material mixture containing the masterbatch and an electrode active material” is blended with “a dispersion medium” to form “[a]n electrode material mixture paste.” LGES-1004, [0023]. The masterbatch contains nanotubes dispersed in a resin, where the aspect ratio of the nanotubes and the ratio of nanotubes to electrode active material are as taught by Ohata. *See id.*, [0015], [0020], [0024]; LGES-1003, ¶33.

In the combination, the nanotubes used in preparation of the masterbatch (*see* LGES-1004, [0015]) are functionalized, *e.g.*, “by carboxylic groups,” as taught by Kavan, such that “[t]he amount of atomic oxygen present” on the nanotube surface is “7%.” LGES-1005, Abstract, 2, 4. These oxidized nanotubes are then “unraveled and straightened by blending them with a resin” to form a

masterbatch, based on Ohata. LGES-1004, [0016]; *see* [0021]; LGES-1003, ¶¶34-36.

Based on Ohata, “an electrode material mixture containing the masterbatch and an electrode active material” is blended with “a dispersion medium” to form “[a]n electrode material mixture paste.” LGES-1004, [0023]. Ohata indicates that “[t]he positive electrode active material” or “[t]he negative electrode active material to be used” in this mixture “varies depending on the battery type.” LGES-1004, [0026]-[0027]. Consistent with this flexibility, in Ohata-Kavan, the negative electrode material mixture paste incorporates titania (TiO₂), *e.g.*, “[t]itanium dioxide P90 ... powder,” as the negative electrode active material, as taught by Kavan. LGES-1005, 2; LGES-1003, ¶37. Alternatively, a positive electrode material mixture paste incorporates a phosphate olivine, *e.g.*, LiFePO₄ or LiMnPO₄, as the positive electrode active material, as also taught by Kavan. LGES-1005, 2; LGES-1003, ¶¶37-38.

4. Reasons for the combination

Reasons for incorporation of oxidized nanotubes

A POSITA would have been motivated to use oxidized nanotubes in the Ohata-Kavan paste. LGES-1003, ¶¶39-49.

First, when the combination paste is a negative electrode material mixture paste having TiO₂ as the active material (*see* LGES-1005, 2), oxidized nanotubes

provide a “beneficial effect of nanotube networking.” LGES-1005, 5; *see* Fig. 5; LGES-1003, ¶40. For instance, “the rate of electrochemical charge transfer is higher” in composites of TiO₂ and oxidized nanotubes as compared to composites with unfunctionalized nanotubes. LGES-1005, 9. A POSITA would have been motivated to use oxidized nanotubes together with TiO₂ such that the combination paste would enjoy fast electrochemical charge transfer. LGES-1003, ¶40.

Second, again when the combination paste is a negative electrode material mixture paste having TiO₂ as the active material (*see* LGES-1005, 2), oxidized nanotubes “exhibit better affinity towards TiO₂” than do unoxidized nanotubes. LGES-1005, Abstract. A POSITA would have been motivated to use oxidized nanotubes together with TiO₂ to obtain a combination paste with a robust interaction between the nanotubes and the electrode active material, which is beneficial for both electrochemical performance and mechanical stability, as explained by Dr. Zhu. LGES-1003, ¶41 (citing LGES-1037, 4).

Third, when the combination paste is instead a positive electrode material mixture paste having a phosphate olivine as the active material (*see* LGES-1005, 2), electrochemical performance of an electrode is improved by oxidized nanotubes. LGES-1003, ¶42. For instance, Kavan reports that “the LiFePO₄ olivine exhibits excellent performance in a composite with MWNT-ox,” with “impressive values” for the capacity of the LiFePO₄/MWNT-ox composite.

LGES-1005, 7; *see* 8 (“It is obvious that the functionalization of nanotubes is, indeed, crucial for enhancing the electrochemical activity of the composite materials with LiFePO_4 ”), 7, Figs. 8 and 10. A POSITA would have been motivated to incorporate oxidized nanotubes into the combination paste to achieve the apparent dramatic performance advantages taught in Kavan. LGES-1003, ¶42.

Fourth, a POSITA would have been motivated to use oxidized nanotubes in furtherance of Ohata’s goal to have well-dispersed nanotubes in the composite. LGES-1003, ¶43. Ohata’s masterbatch process is designed to generate an electrode material paste with dispersed nanotubes, *e.g.*, because of the electrical and mechanical advantages they may be able to provide: “The unraveled and straightened carbon nanotubes 102 are expected to form an excellent conductive path in an electrode even if the amount thereof is small. The resin with the unraveled and straightened carbon nanotubes dispersed therein also serves to increase the mechanical strength of an electrode plate.” LGES-1004, [0016]-[0017]; LGES-1003, ¶43. Oxidized nanotubes are consistent with this objective: they can be more readily dispersible than unfunctionalized nanotubes, as explained by Dr. Zhu. LGES-1003, ¶¶44-45 (citing LGES-1044, 1854; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1007, [0027]). A POSITA would have been motivated to use oxidized nanotubes because, at least in some cases, doing so is

consistent with, and can enhance, Ohata's goal of dispersed nanotubes in the masterbatch. LGES-1003, ¶46.

Fifth, a POSITA would have been motivated to use oxidized nanotubes in the combination paste because oxidative treatments can "remove amorphous carbon and metallic impurities," thus leading to a higher-purity starting material. LGES-1010, 2; LGES-1003, ¶47.

Sixth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (oxidized nanotubes in an electrode composition) to a known structure (Ohata's electrode material paste, which already includes nanotubes) to yield predictable results (a electrode material paste including oxidized nanotubes). LGES-1003, ¶48; *see KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) (a supposed invention that "simply arranges old elements with each performing the same function it had been known to perform" is obvious).

A POSITA would have expected success in incorporating oxidized nanotubes into the Ohata-Kavan paste. LGES-1003, ¶50-52.

First, use of oxidized nanotubes in compositions for lithium ion battery electrodes was conventional. *See* LGES-1003, ¶51 (citing LGES-1005, Abstract, 9; LGES-1032, 3:28-52).

Second, the composition of Kavan's slurry is generally similar to the composition of Ohata's electrode material paste, as explained by Dr. Zhu. *See* LGES-1004, [0022], [0024], [0032]; LGES-1005, 2, 7. These similarities would have provided the POSITA with a reasonable expectation that oxidized nanotubes, as taught in the context of Kavan's slurry, would be compatible with Ohata's electrode material paste. LGES-1003, ¶52.

Reasons for use of TiO₂ or a phosphate olivine as the electrode active material

A POSITA would have been motivated to use TiO₂ as the negative electrode active material in the Ohata-Kavan paste. LGES-1003, ¶¶53-60.

First, TiO₂ is a conventional negative electrode active material, and a POSITA would have been motivated to use TiO₂ because it is common and well-characterized. LGES-1003, ¶54. Indeed, Kavan identifies TiO₂ as among "the top interesting host structures for lithium insertion." LGES-1005, 1; *see* LGES-1040, 1. LGES-1003, ¶54.

Second, a POSITA would have recognized TiO₂ as a desirable negative electrode active material in the Ohata-Kavan paste because the combination of TiO₂ and oxidized nanotubes produces a synergistic effect on electrochemical performance. LGES-1003, ¶55. For instance, Kavan shows that "the electrochemical performance of TiO₂ is improved by nanotube networking," and specifically, that "the composite [of TiO₂] with functionalized nanotubes shows

unique faradaic pseudocapacitance.” LGES-1005, Abstract; *see* 1, 9; LGES-1003,

¶55. The Ohata-Kavan composition includes nanotubes, and a POSITA would have been motivated to incorporate TiO₂ as the negative electrode active material in that composition to obtain those electrochemical performance advantages attributed to this unique TiO₂-oxidized nanotube. LGES-1003, ¶55.

Third, TiO₂ has desirable electrochemical performance characteristics, including high energy density, good cycling performance, and rapid charge/discharge velocity. *See* LGES-1033, Abstract (“We investigate the properties of nanosized TiO₂ rutile by electrochemical methods and thermal analysis. The material shows a high capacity, high rate performance and excellent cycling stability”), 1 (“TiO₂ materials have become an interesting anode material for lithium-ion batteries with unique properties such as high power densities, cheapness, safety and non-toxicity”); LGES-1003, ¶56.

Fourth, TiO₂ undergoes a relatively small volume change during lithium intercalation and deintercalation, and thus TiO₂ electrodes are structurally durable. LGES-1003, ¶57 (citing LGES-1040, 1).

Fifth, TiO₂ is a desirable electrode active material because of its robust safety profile and its low toxicity. *See* LGES-1033, Abstract, 1; LGES-1003, ¶58.

Sixth, TiO₂ is relatively inexpensive, making it an attractive material for use in lithium ion batteries. *See* LGES-1033, 1; LGES-1003, ¶59.

Seventh, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (TiO₂ as an electrode active material in lithium ion battery electrode composition) to a known structure (Ohata's negative electrode material paste) to yield predictable results (a negative electrode material paste including TiO₂ as the electrode active material). LGES-1003, ¶60; *see KSR*, 550 U.S. at 417.

Alternatively, a POSITA would have been motivated to use a phosphate olivine as the positive electrode active material in the Ohata-Kavan paste. LGES-1003, ¶¶61-67.

First, a POSITA would have recognized phosphate olivines—*e.g.*, specifically LiFePO₄—as desirable positive electrode active materials specifically in the Ohata-Kavan paste because of their good electrochemical performance when combined with oxidized nanotubes, as described by Kavan. LGES-1003, ¶62. Kavan notes that “the LiFePO₄ olivine exhibits excellent [electrochemical] performance in a composite with MWNT-ox.” LGES-1005, 7; *see* Abstract; LGES-1003, ¶62 (citing LGES-1042, Abstract).

Second, phosphate olivines are desirable electrode active materials because of their robust safety profile. *See* LGES-1005, 1 (“the phosphate olivines ... are promising cathode materials for Li-ion batteries due to high safety”), LGES-1034, [0004]; LGES-1003, ¶63.

Third, phosphate olivines are economically desirable electrode active materials. *See* LGES-1005, 1 (“the phosphate olivines ... are promising cathode materials for Li-ion batteries due to ... low cost”), LGES-1034, [0004]; LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶64.

Fourth, phosphate olivines are desirable electrode active materials because they are environmentally friendly and generally non-toxic: “the phosphate olivines ... are promising cathode materials for Li-ion batteries due to ... environmental tolerability.” LGES-1005, 1; *see* LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶65.

Fifth, phosphate olivines such as LiFePO_4 have good electrochemical performance, such as high capacity, long cycle life, and stability. *See* LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶66.

Sixth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (a phosphate olivine as an electrode active material in lithium ion battery electrode composition) to a known structure (Ohata’s positive electrode material paste) to yield predictable results (a positive electrode material paste including phosphate olivine as the electrode active material). LGES-1003, ¶67; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating TiO_2 (for a negative electrode material mixture) and/or a phosphate olivine (for a positive electrode material mixture) into the Ohata-Kavan paste. LGES-1003, ¶¶68-71.

First, use of either TiO₂ or phosphate olivines in compositions for lithium ion battery electrodes was conventional, and these materials were well-characterized as electrode active materials. *See* LGES-1003, ¶69 (citing LGES-1033, 1; LGES-1034, [0004]; LGES-1041, Abstract).

Second, Ohata indicates that various electrode active material compositions can be used with its paste: “The negative electrode active material to be used also varies depending on the battery type.” LGES-1004, [0027]; *see* [0026] (“The positive electrode active material to be used varies depending on the battery type.”). Given this flexibility, and the conventional nature of TiO₂ and phosphate olivines as electrode active materials as noted *supra*, a POSITA would have expected these materials to be compatible with Ohata’s paste. LGES-1003, ¶70.

Third, the composition of Kavan’s slurry is generally similar to the composition of Ohata’s electrode material paste, as previously discussed. *See* LGES-1004, [0022], [0032]; LGES-1005, 2; LGES-1003, ¶71. This similarity would have provided the POSITA with a reasonable expectation that either TiO₂ or phosphate olivines, as taught in the context of Kavan’s slurry, could be used with Ohata’s electrode material paste. LGES-1003, ¶71.

5. Analysis

(i) Claim 1

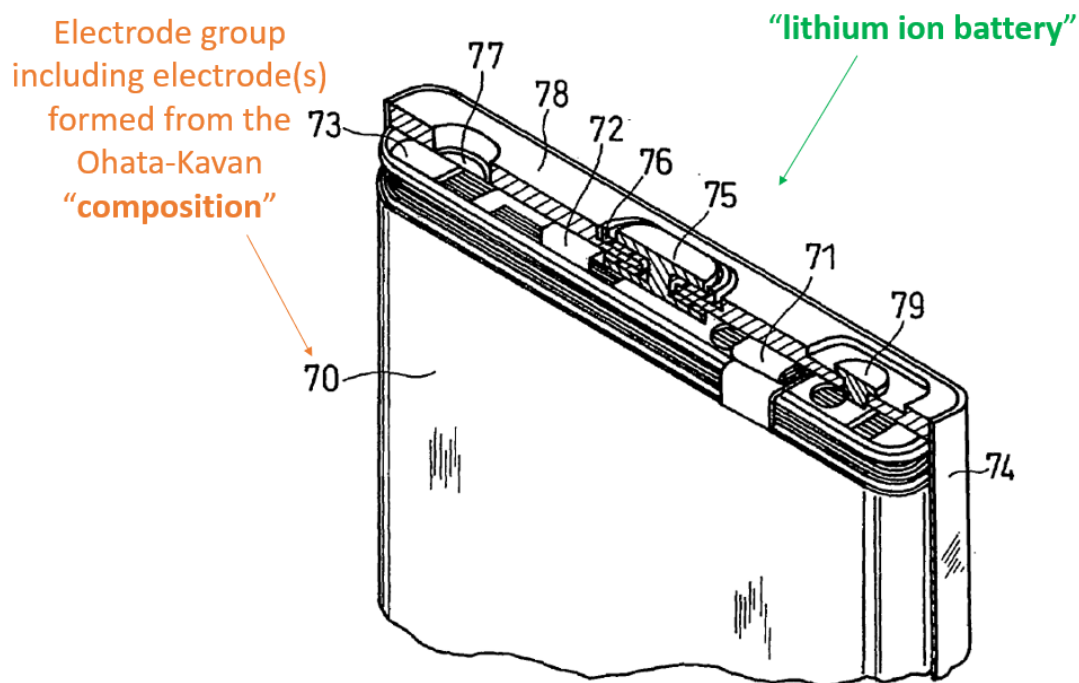
[1pre]

To the extent the preamble is deemed to be limiting, Ohata-Kavan renders it obvious. LGES-1003, ¶¶72-75.

First, Ohata-Kavan renders obvious a **composition** based on Ohata's "electrode material mixture paste." LGES-1004, Abstract; *see* [0005]; LGES-1003, ¶73. The combination **composition** includes "a masterbatch comprising at least carbon nanotubes and a resin" and "an electrode active material," as taught by Ohata. LGES-1004, [0005]; *see* [0022], Abstract, [0016], [0021]-[0022], [0030]-[0032], [0040]-[0042], [0046], claim 1. Consistent with Ohata, the electrode active material of the combination composition can be "a negative electrode active material" or "a positive electrode active material," implemented as TiO₂ or a phosphate olivine, based on Kavan. LGES-1004, [0007]-[0008]; *see* [0026]-[0027], claims 4-5; LGES-1005, Abstract, 2; *see* [1b], *infra*; LGES-1003, ¶73.

Based on Ohata, the combination paste (a **composition**) is used to produce "[a]n electrode for a battery superior in conductivity," *e.g.*, the composition is **useful for lithium ion batteries**. LGES-1004, Abstract; *see* [0017], [0005], [0015], [0026]-[0027], [0032], [0036]-[0037], [0039], [0046]-[0047], claim 1, FIG. 2 (*infra*, showing a "prismatic non-aqueous electrolyte secondary battery"); LGES-1003, ¶¶74-75 (citing LGES-1005, 1-2; LGES-1033, 1; LGES-1034, [0004]).

FIG. 2

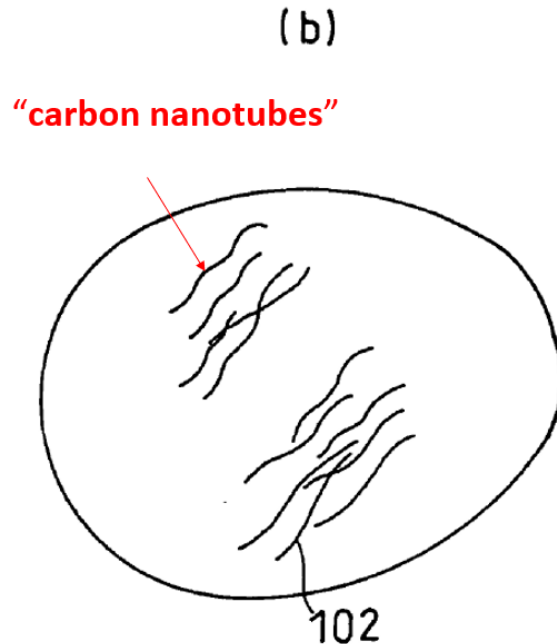


Ohata, FIG. 2 (annotated)

[1a]

The combination composition includes carbon nanotubes

Ohata's "masterbatch" includes "**carbon nanotubes** and a resin," as shown in Fig. 1(b), *infra*. LGES-1004, Abstract; *see* [0015]-[0022], [0005]-[0006], [0030], claim 1, claim 3; LGES-1003, ¶76.



Ohata, Fig. 1(b) (annotated)

The combination composition (based on Ohata’s electrode material mixture paste; *see* [1pre]) is formed by “blending an electrode material mixture containing at least the masterbatch and an electrode active material with a dispersion medium.” LGES-1004, Abstract; *see* [0005], [0023], [0032], claim 1; LGES-1003, ¶77. Because the masterbatch in the combination includes **carbon nanotubes**, the combination electrode material mixture paste (*e.g.*, the Ohata-Kavan **composition**) likewise includes **carbon nanotubes**. *See* LGES-1004, [0024], [0007]-[0008], [0060]-[0061]; LGES-1003, ¶¶77-79.

The carbon nanotubes in the combination composition are discrete

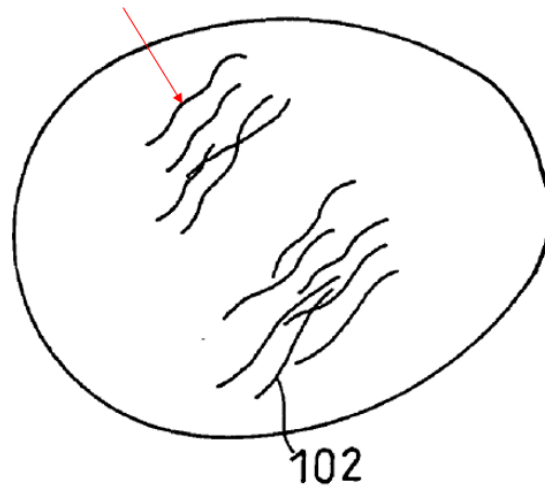
The Ohata-Kavan **composition** includes the masterbatch, which contains **discrete** nanotubes, as taught by Ohata. LGES-1003, ¶80. Ohata describes

“producing a masterbatch by blending at least carbon nanotubes with a resin.”

LGES-1004, [0015]. Prior to this blending, the nanotubes “are tangled and twisted with one another.” *Id.*, [0016]; *see* FIG. 1(a). By “blending them with a resin” to form the masterbatch, “[t]he carbon nanotubes are ***unraveled and straightened.***”

Id., FIG. 1(b), *infra*. The result is a “resin with the unraveled and straightened carbon nanotubes ***dispersed therein,***” *e.g.*, a masterbatch containing **discrete carbon nanotubes**. *Id.*, [0017]; *see* [0016], [0022] (“As the resin in which ***the carbon nanotubes are dispersed,*** a fluorocarbon resin can be used”), [0002] (“to reduce the amount of conductive material used, it is proposed to use a masterbatch process, whereby ***a conductive material is uniformly predispersed in a binder***”); LGES-1003, ¶80. For instance, to the extent **discrete** is interpreted as referring to nanotubes that are generally individually distinct, a POSITA would have found it obvious that at least some of these “unraveled and straightened carbon nanotubes” are **discrete** because they are generally “dispersed” as individual nanotubes in the resin, as described and illustrated by Ohata. LGES-1004, [0017]; *see* LGES-1001, 1:42-44; LGES-1003, ¶80.

“discrete carbon nanotubes”



Ohata, Fig. 1(b) (annotated)

Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidation of nanotubes can help promote non-agglomeration of nanotubes. *See* [1d], *infra*; LGES-1003, ¶81. Oxidized nanotubes are functionalized by species such as carboxylic acid or hydroxyl groups. *See* LGES-1010, Abstract; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1007, [0027]-[0028]; LGES-1003, ¶82. As indicated by these references and as explained by Dr. Zhu, the presence of these functionalities can contribute to physically and chemically inhibiting aggregation of nanotubes into clumps; instead, oxidized nanotubes are generally present as individually distinct nanotubes. LGES-1003, ¶82. In light of this behavior of oxidized nanotubes, a POSITA would have understood or found obvious that oxidized nanotubes in the

combination can be present as generally individually distinct nanotubes, *e.g.*, that the nanotubes are **discrete**. LGES-1003, ¶83.

[1b]

The combination composition (based on Ohata's electrode material mixture paste; *see* [1pre]) is formed by "blending an electrode material mixture containing at least the masterbatch and ***an electrode active material*** with a dispersion medium." LGES-1004, Abstract; *see* [0005], [0023], [0032], claim 1, claims 8-10. The electrode active material, *e.g.*, either a "negative electrode active material" or a "positive electrode active material," corresponds to **lithium ion active material**. LGES-1004, [0026]-[0027]; LGES-1003, ¶84. The specific composition of this electrode active material as either TiO₂ or a phosphate olivine is based on Kavan, as discussed *infra*. LGES-1003, ¶84.

Lithium ion active material for negative electrodes

The negative electrode active material (the **lithium ion active material**) in the Ohata-Kavan paste is titanium dioxide (TiO₂) based on Kavan's teachings of forming a "paste" including "nanotubes" and "***TiO₂***." LGES-1005, 2; LGES-1003, ¶85; *see* LGES-1004, [0027]; LGES-1005, 2-3, 9, 5, Abstract ("Multi-walled carbon nanotubes functionalized by carboxylic groups, exhibit better affinity towards ***TiO₂***").

TiO₂ is a **lithium ion active material**, as confirmed by Kavan: “**TiO₂** ... belong to the top interesting host structures for **lithium insertion**.” LGES-1005, 1; *see* 2 (“Since **TiO₂ is a prospective anode material** ..., concerted study of the interaction of MWNT with” TiO₂ “is relevant for the development of high-power Li-ion batteries.”); LGES-1003, ¶86.

Consistent with Kavan, in the combination electrode material paste, “[a]ll nanotubes are covered with individual **nanocrystals of P90** in a homogeneous nanocomposite,” *e.g.*, the TiO₂ (**lithium ion active material**) is present in the combination composition as **crystals**. LGES-1005, 3; *see* 4 (“industrial powder (P90) is a good source of **nanocrystals** which spontaneously self-assemble on the nanotube surface”), 1 (“Carbon nanotubes form conductive composites with inorganic **nanocrystals**”); LGES-1003, ¶¶87-88.

Based on Kavan, the nanotubes in the combination electrode material paste have TiO₂ nanocrystals (**crystals of lithium ion active material**) **attached to their surface**. LGES-1003, ¶89. For instance, the TiO₂ nanocrystals are attached to the nanotube surface due at least in part to the surface oxidation of the nanotubes (*see* [1d], *infra*): “oxidative functionalization through HNO₃ is crucial for **proper anchoring of nanotubes towards TiO₂**”). LGES-1005, 3-4; *see* 2 (“The surface oxidation of carbon nanotubes by HNO₃, H₂SO₄/HNO₃ or H₂O₂, producing among other groups also carboxyls, was sometimes mentioned to improve **the anchoring**

of TiO₂”), 4-5, 9, Abstract; LGES-1003, ¶89. For instance, as explained by Dr.

Zhu, this **attachment** can be through covalent bonding. LGES-1003, ¶¶90-91 (citing LGES-1030, Abstract; LGES-1037, 4). Moreover, there are Van der Waals forces and hydrogen bonding between the TiO₂ and the functional groups on the nanotube surfaces (*see* LGES-1037, 4); to the extent either of these is considered an attachment, the TiO₂ is alternatively/additionally **attached** to the nanotubes through Van der Waals forces and/or hydrogen bonding. LGES-1003, ¶¶92-93.

Lithium ion active material for positive electrodes

Alternatively, the positive electrode active material (the **lithium ion active material**) in the Ohata-Kavan paste is a phosphate olivine such as LiMnPO₄ or LiFePO₄ based on Kavan’s teachings of forming a “paste” including “nanotubes” and “*LiMnPO₄ or LiFePO₄*.” LGES-1005, 2; LGES-1003, ¶94; *see* LGES-1004, [0026]; LGES-1005, 2 (describing use of “carbon-free olivines, LiFePO₄ or LiMnPO₄ in fabricating samples), 4, 6-9.

Phosphate olivines such as LiMnPO₄ and LiFePO₄ are each a **lithium ion active material**, as confirmed by Kavan: 2 (“*LiMPO₄ olivines are promising cathode materials*”), 1. LGES-1003, ¶95.

Consistent with Kavan, in the combination electrode material paste, these phosphate olivines (**lithium ion active material**) are present in the combination composition as **crystals**: “the naked nanotubes are easily recognized between the

individual crystals of LiMnPO₄ ... as well as between *LiFePO₄ crystals*.” LGES-1005, 4; *see id.* (“the *olivine crystals* are typically hundreds of nm in size”), 1; LGES-1003, ¶¶96-97.

Based on Kavan, the nanotubes in the combination electrode material paste have phosphate olivine crystals (**crystals of lithium ion active material**) **attached to their surface**. LGES-1003, ¶98. The phosphate olivine crystals are attached to the nanotube surface due at least in part to the surface oxidation of the nanotubes (*see* [1d], *infra*): “The surface oxidation of carbon nanotubes ... was sometimes mentioned to improve *the anchoring of ... LiMnPO₄*.” LGES-1005, 2; *see id.* (“MWNT functionalization (by surface oxidation forming carboxyls) for *optimum attachment of MWNT towards ... olivine surfaces*”), 4; LGES-1003, ¶98.

[1c]⁴

In Ohata-Kavan, the nanotubes “have an aspect ratio determined by dividing the average length of the carbon nanotubes by the average diameter of the same of *not less than 100*” and “preferably *not greater than 1000*,” based on Ohata. LGES-1004, [0020]; *see* [0006], [0009], [0010], claim 2, claims 9-10; LGES-1003,

⁴ Petitioner has applied art consistent with Patent Owner’s assertions in the Infringement Contentions, without necessarily agreeing with Patent Owner’s interpretation of the claim language. *See generally* LGES-1050.

¶99. For instance, the nanotubes of the combination can have an aspect ratio of **50** (LGES-1004, Table 2, *infra*), **100** (*id.*, [0030], Table 2), or **200** (*id.*, Table 2).

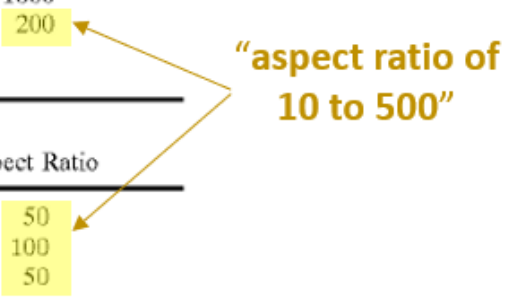
LGES-1003, ¶¶99, 102.

TABLE 2		
	Diameter of CNT (μm)	Aspect Ratio
Ex. 10	0.01	1000
Ex. 11	0.05	200

TABLE 2-continued

	Diameter of CNT (μm)	Aspect Ratio
Ex. 12	0.05	50
Ex. 13	0.1	100
Ex. 14	0.1	50

CNT: Carbon nanotube



“aspect ratio of 10 to 500”

Ohata, Table 2

The specific aspect ratios of **50**, **100**, and/or **200** (*see* LGES-1004, [0030], Table 2) for nanotubes of the Ohata-Kavan combination fall within the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶100. In the combination, these specific aspect ratios disclosed by Ohata are thus a relevant disclosure for the recited range of aspect ratios. *See Ineos USA LLC v. Berry Plastics Corp.*, 783 F.3d 865, 869 (Fed. Cir. 2015) (“When a patent claims a range, as in this case, that range is anticipated by a prior art reference if the reference discloses a point within the range”); *Titanium Metals Corp. of Am. v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985); *In re Petering*, 301 F.2d 676, 682 (1962). Thus, Ohata-Kavan renders

obvious that the nanotubes in the combination composition have **an aspect ratio of 10 to 500**.

Alternatively/additionally, the range of aspect ratios (“*not less than 100*” and “*not greater than 1000*”) for the nanotubes of the Ohata-Kavan combination overlaps with the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶¶101-102. The ’909 Patent provides no indication of criticality or unexpected results associated with the claimed range of aspect ratios. LGES-1003, ¶101. Thus, the overlapping range of ratios of the nanotubes of the combination presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (“A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art”); *In re Geisler*, 116 F.3d 1465, 1469–70 (Fed. Cir. 1997) (“When an applicant seeks to overcome a *prima facie* case of obviousness by showing improved performance in a range that is within or overlaps with a range disclosed in the prior art, the applicant must ‘show that the [claimed] range is *critical*, generally by showing that the claimed range achieves unexpected results relative to the prior art range’” (quoting *In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990) (alteration and emphasis in original))).

[1d]

The nanotubes in the combination composition are **oxidized** based on Kavan. LGES-1003, ¶103. For instance, the nanotubes are “*functionalized by oxidation* with HNO₃.” LGES-1005, 2. The result of this oxidation process is “nanotubes functionalized by carboxylic groups.” *Id.*, Abstract; *see* 2, 4, 9. These oxidized nanotubes are used in preparation of the masterbatch based on Ohata (*see* LGES-1004, Abstract, [0015]-[0016]) and thus are present in the combination composition. LGES-1003, ¶103.

The oxidized nanotubes in the combination composition, functionalized as described by Kavan (*see* LGES-1005, 2), have 7% “atomic oxygen present” on their surface as “analyzed by X-ray photoelectron spectroscopy [XPS].” *Id.*, 4; *see* 2; LGES-1003, ¶104. As explained by Dr. Zhu, one method of determining the **oxidation level by weight of the nanotubes** is by calculating the weight of the oxygen atoms attached to the nanotubes divided by the total weight of the oxidized nanotubes. LGES-1003, ¶¶14-17. Based on this method, the specific case of Kavan’s 7 atomic percent oxygen corresponds to an **oxidation level of 9.1% by weight of the carbon nanotube**. LGES-1003, ¶¶104-106.

This oxidation level value (9.1% by weight) (*see* LGES-1005, 4) for nanotubes of the Ohata-Kavan combination falls within the recited range of oxidation levels (**1% to 15% by weight**). LGES-1003, ¶107. In the combination,

this specific oxidation level disclosed by Kavan, and applied to the nanotubes of the combination, is thus a relevant disclosure for the recited range of oxidation levels. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782. Thus, Ohata-Kavan renders obvious a composition in which the nanotubes have **oxidation levels from 1% to 15% by weight of the carbon nanotube.**

Kavan's 9.1% by weight oxidation level is determined by calculating the weight of the oxygen atoms attached to the nanotubes divided by the total weight of the oxidized nanotubes. LGES-1003, ¶105. As Dr. Zhu explains, other approaches are also available to calculate oxidation levels by weight. LGES-1003, ¶¶14-17. While the '909 Patent does not identify a specific approach for determining oxidation levels, a POSITA would have recognized or otherwise found obvious that the foregoing calculation is one reasonable and well-known way to determine oxidation levels for nanotubes such as those disclosed by Kavan (although there are other calculation methods that would also be reasonable). *Id.*

Moreover, while the oxidation levels of Kavan's nanotubes are measured using XPS (*see* LGES-1005, 4), other experimental techniques are available for measuring oxidation levels of nanotubes. LGES-1003, ¶¶14-17. Again, while the '909 Patent does not identify a specific characterization technique to be used for determining oxidation levels, a POSITA would have recognized or otherwise found obvious that XPS characterization of oxidation levels is one reasonable and

well-known way to determine oxidation levels for nanotubes such as those disclosed by Kavan (although there are other methods of characterization that may be appropriate in some circumstances). LGES-1003, ¶¶14-17 (citing LGES-1010, 6; LGES-1009, 4).

(ii) Claim 2

When the Ohata-Kavan composition is a negative electrode material, the lithium ion active material is ***TiO₂***, *i.e.*, the crystals or layers of lithium ion active material comprise **titanium**. *See* [1b], *supra*; *see* LGES-1005, Abstract, 2-3, 5, 9; LGES-1003, ¶108.

(iii) Claim 5

In the Ohata-Kavan composition, the weight percentage of the carbon nanotubes is specified by Ohata, which teaches that “***[t]he amount of the carbon nanotubes*** contained in the electrode material mixture is, for example, ***0.2 to 3 parts by weight per 100 parts by weight of the electrode active material.***” LGES-1004, [0024]. Notably, this range of “0.2 to 3 parts by weight” applies to both negative electrode active materials (*see id.*, [0008], [0010], claim 5) and positive electrode active materials (*see id.*, [0007], [0009], claim 4). LGES-1003, ¶109.

Ohata’s weight percentage range (0.2 to 3 parts by weight nanotubes per 100 parts by weight electrode active material) corresponds to the nanotubes being present in a weight percentage of 0.2% (0.2 parts nanotubes per 100 parts lithium

ion active material) to 3.0% (3:100) by weight of the lithium ion active material.

LGES-1003, ¶110. Alternatively/additionally, to the extent the weight percentage is based on the total weight of both nanotubes and lithium ion active material,⁵ Ohata's weight percentage range corresponds to the nanotubes being present in a weight percentage of 0.2% (0.2 parts nanotubes per 100.2 parts total) to 2.9% (3:103) by weight. LGES-1003, ¶110.

This range of weight percentages disclosed by Ohata (**0.2% to 3.0%**) falls within the claimed **0.1% to 10% by weight** range recited in claim 5. LGES-1003, ¶111. As such, in Ohata-Kavan, this specific range of weight percentages disclosed by Ohata is a relevant disclosure for the recited weight percentage range, and Ohata-Kavan thus renders obvious the claimed range of weight percentages. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782.

Ohata also provides specific examples of “[p]ositive electrodes” having compositions shown in Table 1, *infra*. LGES-1004, [0040]. Each of the weight

⁵ The '909 Patent states that “[t]he term ‘weight percent’ or ‘percent weight’ or ‘% by weight’ as used herein is calculated by dividing the weight of a reagent by the total weight of a mixture to which it is added.” LGES-1001, 3:59-62; LGES-1003, ¶110.

percentages given in Table 1 (highlighted in purple) falls within the claimed **0.1% to 10% by weight** range recited in claim 5. LGES-1003, ¶¶112-113.

TABLE 1

	Amount of CNT Per 100 parts by weight of active material (parts by weight)	Amount of MB per 100 parts by weight of active material (parts by weight)	CNT content in MB (wt %)
Ex. 1	0.5	3.3	15
Ex. 2	0.2	1.3	15
Ex. 3	0.3	2	15
Ex. 4	0.8	5.3	15
Ex. 5	1.0	6.7	15
Ex. 6	1.5	7.5	20
Ex. 7	2.0	10	20
Ex. 8	3.0	15	20

CNT: Carbon nanotube
MB: Masterbatch

Ohata, Table 1 (annotated)

Furthermore, Ohata provides a specific example of a negative electrode having “3.3 parts by weight of masterbatch, the same as the one used in the production of the positive electrode in Example 1, 100 parts by weight of flake graphite as an active material and 56 parts by weight of N-methyl-2-pyrrolidone.” [0046]. This weight percentage (0.5% weight percentage of nanotubes by weight of the lithium ion active material) also falls within the claimed **0.1% to 10% by weight** range recited in claim 5. LGES-1003, ¶114.

To the extent that fewer than all of the nanotubes in the Ohata-Kavan composition are discrete carbon nanotubes, a POSITA would have found obvious,

given their oxidation level, that they nevertheless constitute a substantial portion of entire population of nanotubes. Thus, a POSITA would have understood, or at least found obvious, that the recited range of weight percentages (“0.1 to 10% by weight”) still overlaps with, and thus is rendered obvious by, the weight percentage of that subset of the nanotubes that are discrete. LGES-1003, ¶111.

(iv) **Claim 6**

[6a]

See [1a]-[1b], [1d], *supra*; LGES-1003, ¶115.

[6b]

In Ohata’s masterbatch process, “a conductive material is ***uniformly predispersed*** in a binder.” LGES-1004, [0002]. In the combination, this “conductive material” is the oxidized carbon nanotubes, and via Ohata’s masterbatch process, the nanotubes are “***uniformly predispersed***” in the resin. *Id.*, [0002]; *see* [0005], [0015]; LGES-1003, ¶116. This masterbatch, with “uniformly predispersed” nanotubes, is then mixed with an electrode active material and a dispersion medium to form the combination paste. LGES-1004, [0002]; *see* [0023]; LGES-1003, ¶116.

In the combination, a POSITA would have understood, or at least found obvious, that the nanotubes remain ***uniformly dispersed*** in the combination paste. LGES-1003, ¶117. For instance, a POSITA would have recognized that the

combination manufacturing process based on Ohata, in which the masterbatch is blended with “an electrode active material” and “a dispersion medium” to form an electrode material mixture paste (LGES-1004, [0023]), would allow the nanotubes in the resulting paste to remain **uniformly dispersed**, as they are in the masterbatch. LGES-1003, ¶117.

Moreover, a POSITA would have understood, or at least found obvious, that the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**.⁶ Ohata’s Fig. 1(b), again *infra*, which a POSITA would have understood as representative of the nanotube arrangement in the combination paste, as discussed in the previous paragraph, shows that the nanotubes are dispersed **without clustering**, *e.g.*, in that the nanotubes are present as generally individual

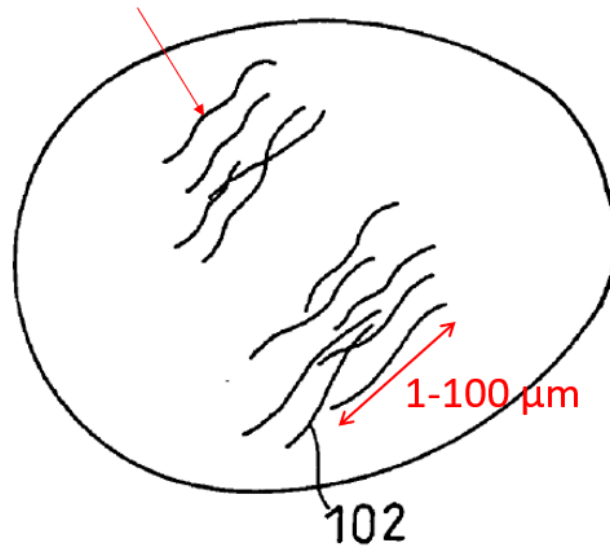
⁶ The ’909 Patent provides no substantive discussion of this feature. It is inappropriate to hold the prior art to a stricter standard of disclosure than what is disclosed in the specification of the patent itself. *See In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994) (“the Board’s observation that appellant did not provide the type of detail in his specification that he now argues is necessary in prior art references supports the Board’s finding that one skilled in the art would have known how to implement the features of the references and would have concluded that the reference disclosures would have been enabling”).

nanotubes. LGES-1003, ¶118. Thus, because there is no clustering, a POSITA would have understood that the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. *Id.*

Moreover, although no scale is provided for the Fig. 1(b) schematic illustration, a POSITA would have been able to estimate the scale based on Ohata's disclosure that the nanotubes "have an average length of 1 to 100 μm ." LGES-1004, [0019]; LGES-1003, ¶118. For instance, for nanotubes having a length of 100 μm , the space between the nanotubes is depicted as greater than 1 μm , *e.g.*, the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. LGES-1003, ¶118. Alternatively/additionally, as confirmed by Ohata's disclosure that the nanotubes are "dispersed," a POSITA further would have understood that the nanotubes in the Ohata-Kavan composition do not form clusters of greater than 1 micrometer in size, *e.g.*, the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. LGES-1003, ¶118.

(b)

“carbon nanotubes”



Ohata, Fig. 1(b) (annotated)

(v) Claim 7

The uniformly dispersed, oxidized carbon nanotubes having crystals or layers of lithium ion active materials attached to their surface (*see* [6], *supra*) are **dispersible** because the combination composition is a paste (based on Ohata’s electrode material mixture paste) that is “prepared by blending an electrode material mixture containing the masterbatch and an electrode active material with a dispersion medium,” *e.g.*, the masterbatch (containing the dispersed nanotubes) and the electrode active material are **dispersible** in the dispersion medium at least because the mixture can be blended. LGES-1004, [0023]; LGES-1003, ¶¶119-120.

Alternatively/additionally, the nanotubes are **dispersible** because they are not attached to a substrate. LGES-1003, ¶121.

(vi) **Claim 8**

In the combination, Kavan renders obvious a **chemical attachment** of lithium ion active material (the titania) to a nanotube surface. Kavan references an “*interaction of carboxyls with titania*” when describing a chemical interaction between the carboxyls on the nanotubes groups and the titania. LGES-1005, 4; *see* Abstract, 4 (“oxidative functionalization ... is crucial for *proper anchoring of nanotubes towards TiO₂*”); LGES-1003, ¶122.

This carboxyl-titania interaction can be a covalent bond. Indeed, the lithium ion active material can be **chemically attached** to the nanotubes by way of a covalent bond. LGES-1003, ¶122 (citing LGES-1030, Abstract, LGES-1037 (J.Li), 4).

Alternatively/additionally, the interaction between carboxyl-titania interaction can be hydrogen bonding and/or Van der Waals forces. LGES-1003, ¶123. To the extent that hydrogen bonding / Van der Waals forces can be considered a chemical attachment, the lithium ion active material is **chemically attached** to the nanotube surface via these bonds/forces. LGES-1003, ¶123.

Separately, when the lithium ion active material is a phosphate olivine, covalent bonds to the nanotubes are created, rendering obvious **chemically attachments**. LGES-1003, ¶124.

B. [GROUND 2A] – CLAIMS 1-2 AND 5-8 ARE OBVIOUS OVER LEE-WEPASNICK

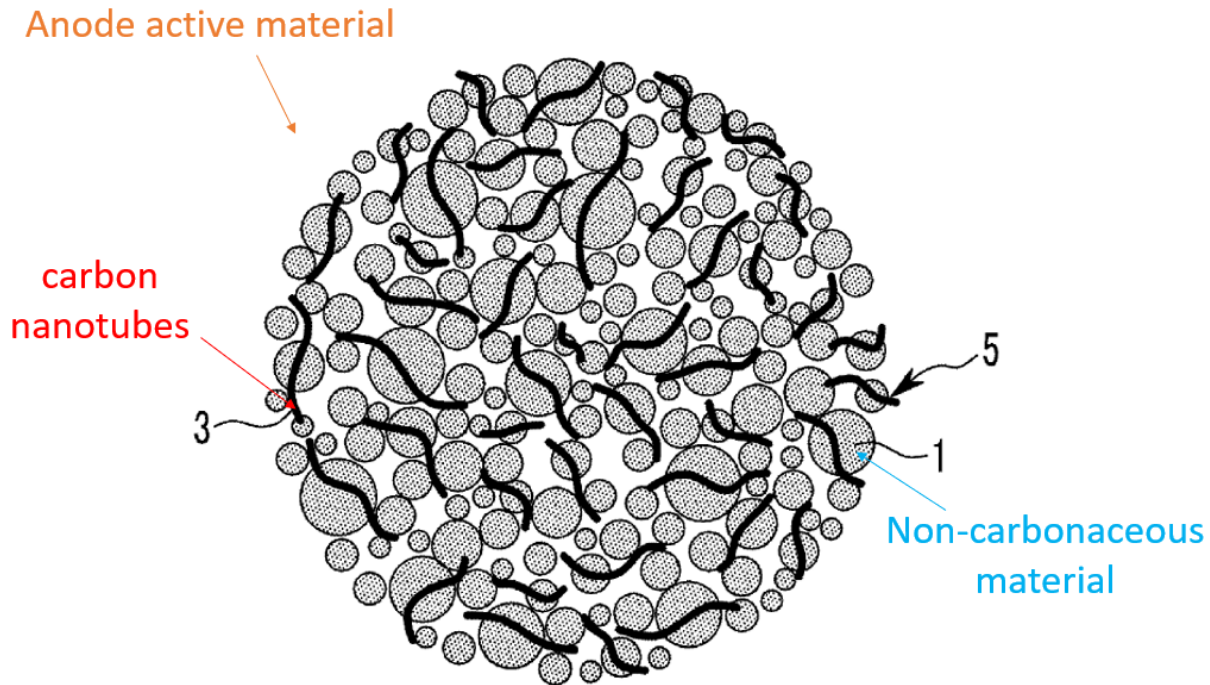
The sections below provide an introduction to Lee, Wepasnick, and their combination.⁷

1. Lee describes an anode active material including carbon nanotubes

Lee describes “an anode active material” for a lithium ion battery. LGES-1006, [0010], FIG. 1, *infra*; LGES-1003, ¶¶125-126. This material includes “secondary particles that are formed by the agglomeration of primary nanoparticles 5.” LGES-1006, [0040]. The primary nanoparticles “include a non-carbonaceous material 1” (blue) “and hollow carbon nanofibers 3” (red) “which are bound to the non-carbonaceous material by Van der Waals forces.” *Id.*, [0040]. The non-carbonaceous material is “a silicon-based material” such as silicon or a silicon-metal alloy that acts as lithium ion active material. *Id.*, [0043]. The “hollow carbon nanofibers” are “carbon nanotubes.” *Id.*, [0046]; LGES-1003, ¶127.

⁷ Petitioner incorporates this discussion into Grounds 2A-2B.

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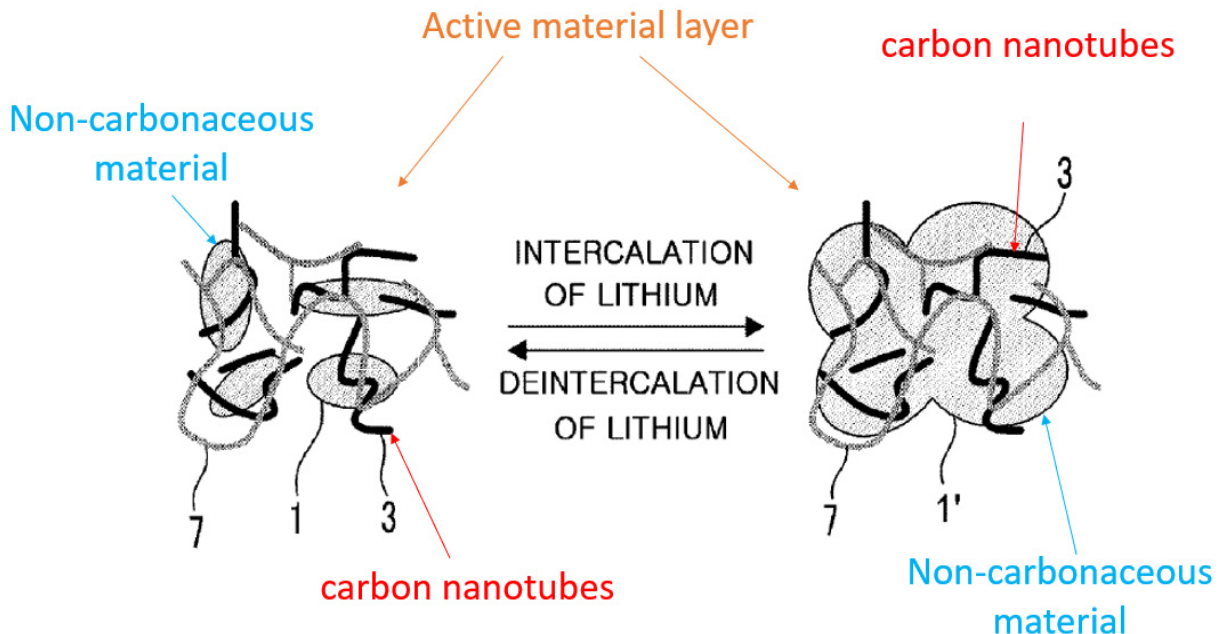


Lee, FIG. 1 (annotated)

In the anode active material, “the non-carbonaceous material 1 is bound to the hollow carbon nanofibers to form a composite material” that has “a higher electrical conductivity,” *e.g.*, to obtain the “higher capacity” of non-carbonaceous lithium ion active materials while compensating for their “lower electrical conductivity” as compared to “conventional carbonaceous anode materials.” LGES-1006, [0042]-[0043]; LGES-1003, ¶128.

The anode active material, a binder, and a solvent are combined into “an anode active material composition” such as a slurry. LGES-1006, [0064]; *see* [0085]. This slurry “is coated on a current collector as part of a process to form

“an active material layer of an anode.” *Id.*, [0065]; *see* [0049]. The structure of the active material layer of the anode is shown in FIG. 3, *infra*. As illustrated, “a composite of Li and the non-carbonaceous material 1 [] is generated during charging of the anode.” *Id.*, [0051]; LGES-1003, ¶129.



Lee, FIG. 3 (annotated)

In Lee’s anode active material composition, the polymeric binder has “an electron donor group” that “aids the dispersal of the hollow carbon nanofibers 3” and allows for “the hollow carbon nanofibers 3 [to] be bound with the binder 7, by charge transfer bonding.” *Id.*, [0052]-[0053]. This bonding between nanofibers and binder “enhances interparticle cohesion,” such that “even if the volume of the non-carbonaceous material 1 changes, due to the intercalation/de-intercalation of lithium, the structure of the anode active material 10 can be maintained,” and thus

“the cycle lifetime characteristics may be improved.” *Id.*, [0053]; *see* [0054], [0058]; LGES-1003, ¶130. For instance, Lee explains that when “conventional anodes include a non-carbonaceous material, such as Si,” are used, intercalation of lithium can “lead[] to abrupt volumetric changes in the crystalline lattice of Si, thereby fracturing the conventional active material,” and thus “the discharge capacity markedly decreases.” *Id.*, [0059]. In Lee’s anode active material layer, by contrast, the binding between the binder and the nanofibers, and the binding between nanoparticles, allows “the structure of the active material layer ... [to] be maintained during charging and discharging.” LGES-1006, [0058]; LGES-1003, ¶¶130-131.

2. Wepasnick characterizes oxidation levels of carbon nanotubes treated by various conventional oxidation treatments

Wepasnick is an academic study of the effect of various “commonly used wet chemical oxidants” on “the surface chemistry and structure of MWCNTs.” LGES-1010, Abstract. Wepasnick’s study investigated “the effects of six wet chemical oxidants ... used under different reaction conditions (e.g., w/w%).” LGES-1010, 2-3. The resulting oxidized multiwall nanotubes were characterized using various methods to quantify the atomic concentration of oxygen and the concentrations of carboxylic acid, hydroxyl, and carbonyl groups. *Id.*, 3-4; *see* 6, Fig. 5. Wepasnick’s results demonstrate that the identity and concentration of the

oxidant affect both the oxidation levels of the nanotubes and the distribution of the oxygen-containing functional groups on the nanotubes. *See* LGES-1010, 8-10, Figs. 6-9; LGES-1003, ¶¶132-136.

3. The Lee-Wepasnick combination

In Lee-Wepasnick, an “anode active material” includes carbon nanotubes and a non-carbonaceous material, as described by Lee. LGES-1006, [0040]. The carbon nanotubes are oxidized using one of the “commonly used wet chemical oxidants,” as taught by Wepasnick, thereby functionalizing the nanotube surface with “carboxyl, carbonyl, and hydroxyl groups.” LGES-1010, Abstract; LGES-1003, ¶137. In Lee-Wepasnick, a POSITA would have chosen an oxidative treatment based on Wepasnick’s data about various oxidation treatments to achieve a desired “concentration and distribution of different oxygen functional groups on the CNT surface,” to thereby control “the ultimate structure and properties” of the resulting material. LGES-1010, 2; LGES-1003, ¶137.

The oxidized nanotubes are mixed with a non-carbonaceous material “in an organic solvent,” and “[t]he resultant is then dried to prepare an anode active material,” as taught by Lee. LGES-1006, [0060]; LGES-1003, ¶138. In the combination “anode active material,” the presence of functional groups on the nanotubes supplements the Van der Waals binding between the non-carbonaceous material and the nanotubes, enhancing the structural stability and cycle lifetime of

the anode active material. *See* LGES-1006, [0040] (“hollow carbon nanofibers 3, which are bound to the non-carbonaceous material by Van der Waals forces”), [0044]; LGES-1010, 2 (“the role of oxidation is to create ‘foothold’ functional groups ... which then serve as attachment points to anchor either larger biomolecular structures or nanoparticles”); LGES-1003, ¶138. For instance, the POSITA would have chosen a particular oxidative treatment to achieve a “concentration and distribution of different oxygen functional groups on the CNT surface” that allows for a suitable degree of binding between the nanotubes and the non-carbonaceous material, *e.g.*, while taking into account other target objectives. LGES-1010, 2; LGES-1003, ¶¶138, 140.

This combination “anode active material” is mixed with a polymeric binder to form an “anode active material composition,” which is processed to form an anode for a lithium ion battery, consistent with Lee. *See* LGES-1006, [0064]-[0065]; LGES-1003, ¶139. The presence of oxidized nanotubes is advantageous, in the context of Lee-Wepasnick, in providing structural integrity to the “active material layer” formed from that composition, *e.g.*, because chemical interactions between the nanotubes and the binder enable good cycle lifetime characteristics. LGES-1006, [0049]; *see* LGES-1010, 2 (“the surface of CNTs used in reinforced polymer composites are often modified covalently by the addition of polar functional groups ... to enhance chemical interactions with the resin matrix”);

LGES-1006, [0058] (“The polymeric binder having an electron donor group may enhance the cohesion of anode 20, through the bonding with the hollow carbon nanofibers 3”); LGES-1003, ¶139. For instance, the POSITA would have chosen a particular oxidative treatment based on Wepasnick’s characterization data to achieve a “concentration and distribution of different oxygen functional groups on the CNT surface” that allows for a suitable degree of binding between the nanotubes and the binder. LGES-1010, 2; *See* LGES-1006, [0056], [0053]; LGES-1003, ¶140.

4. Reasons for the combination

A POSITA would have been motivated to use oxidized nanotubes in the Lee-Wepasnick anode active material. LGES-1003, ¶¶141-147.

First, a POSITA, recognizing the importance of the binding between nanotubes and non-carbonaceous material in achieving “higher electrical conductivity” and “excellent cycle lifetime characteristics” (*see* LGES-1006, [0043]-[0044]), would have been motivated to use oxidized nanotubes because the functional groups on the nanotubes would enhance this bonding: “In functionalization strategies, the role of oxidation is to create ‘foothold functional groups, such as carboxyl groups, which then serve as attachment points to anchor ... nanoparticles.” LGES-1010, 2; LGES-1003, ¶142 (citing LGES-1009, 2; LGES-1043, 2-3).

Second, a POSITA also would have recognized the importance of the binding between nanotubes and the polymeric binder in “improving the cycle lifetime characteristics” of the anode active material composition (*see* LGES-1006, [0054]), and similarly would have been motivated to use oxidized nanotubes because the functional groups on the nanotubes would enhance this bonding: “the surface of CNTs used in reinforced polymer composites are often modified covalently by the addition of polar functional groups ... to enhance chemical interactions with the resin matrix.” LGES-1010, 2; LGES-1003, ¶143.

Third, a POSITA would have been motivated to use oxidized nanotubes in because oxidative treatments can “remove amorphous carbon and metallic impurities from as-produced CNTs,” thus leading to a higher-purity starting material. LGES-1010, 2; *see* 11; LGES-1003, ¶144.

Fourth, Wepasnick’s characterization study demonstrates that the nature of the oxidant and the treatment conditions affect both the “concentration and distribution of different oxygen functional groups on the CNT surface,” and notes these characterization results can allow for “better control [of] the ultimate structure and properties of the CNT-based materials.” LGES-1010, 2, 11; *see* Table 1, Figs. 6-9; LGES-1003, ¶145. Moreover, the particular oxidative treatment also impacts “the structure of [the] MWCNTs.” LGES-1010, 11; *see* Fig. 10; LGES-1003, ¶145. A POSITA would have been motivated to select a particular

oxidative treatment (*e.g.*, oxidant and treatment conditions) obtain an overall oxidation level and distribution of functional groups that achieves a target performance goal, while also maintaining sufficient structural integrity of the nanotubes. LGES-1003, ¶145. For instance, in the context of Lee-Wepasnick, a POSITA would have been motivated to select an oxidative treatment that produces an oxidation level, and a composition of oxidative species, that facilitates both bonding between the nanotubes and the non-carbonaceous material (*see* LGES-1006, [0043]-[0044]) and between the nanotubes and the polymeric binder (*see id.*, [0053]-[0054], [0058]-[0059]); LGES-1003, ¶145.

Fifth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (oxidized nanotubes, which are conventionally used in “polymer composites” and as part of “complex nanostructures,” LGES-1010, 2) to a known structure (the nanotubes of Lee’s anode active material) to yield predictable results (an anode active material including oxidized nanotubes). LGES-1003, ¶146; *see KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) (a supposed invention that “simply arranges old elements with each performing the same function it had been known to perform” is obvious).

A POSITA would have expected success in using oxidized nanotubes in the Lee-Wepasnick anode active material. LGES-1003, ¶¶148-152.

First, the oxidation treatments studied by Wepasnick, and the oxidation levels that result from these treatments, are commonly used, and indeed Wepasnick acknowledges the conventional nature of these treatments and of their results. *See* LGES-1010, Abstract (“Six commonly used wet chemical oxidants ... were evaluated”), 3 (“The experimental details of each wet chemical treatment were based upon established procedures used to either oxidize or purify CNTs”), 7, Table 1.; LGES-1003, ¶149 (citing LGES-1009, Abstract, Figs. 4-5).

Second, oxidized nanotubes were commonly used in the context of polymer-based composites—of which the Lee-Wepasnick anode active material composition is an example. *See* LGES-1010, 2; LGES-1003, ¶150.

Third, oxidized nanotubes are compatible with Lee’s compositions. LGES-1003, ¶151. For instance, oxygen functional groups such as carboxylic acids can bind to silicon, silicon oxide, or silicon-metal alloys, and thus a POSITA would have expected oxidized nanotubes to be capable of bonding to a non-carbonaceous material, as described by Lee. *See* LGES-1006, [0043] (“the non-carbonaceous material 1 is bound to the hollow carbon nanofibers”), [0041]; LGES-1003, ¶151. Moreover, oxygen functional groups such as carboxylic acids also can bind to “an amino group, an amide group, [or] a thiol group,” and thus a POSITA would have expected oxidized nanotubes to be capable of bonding to the polymeric binder

described by Lee, which includes one or more of these species. LGES-1006,

[0056]; *see* LGES-1043, 2-3; LGES-1003, ¶151.

Fourth, use of oxidized nanotubes in compositions for lithium ion battery electrodes was conventional. *See* LGES-1005, Abstract, 9; LGES-1032, [0027]-[0031]; LGES-1003, ¶152.

5. Analysis

(i) Claim 1

[1pre]

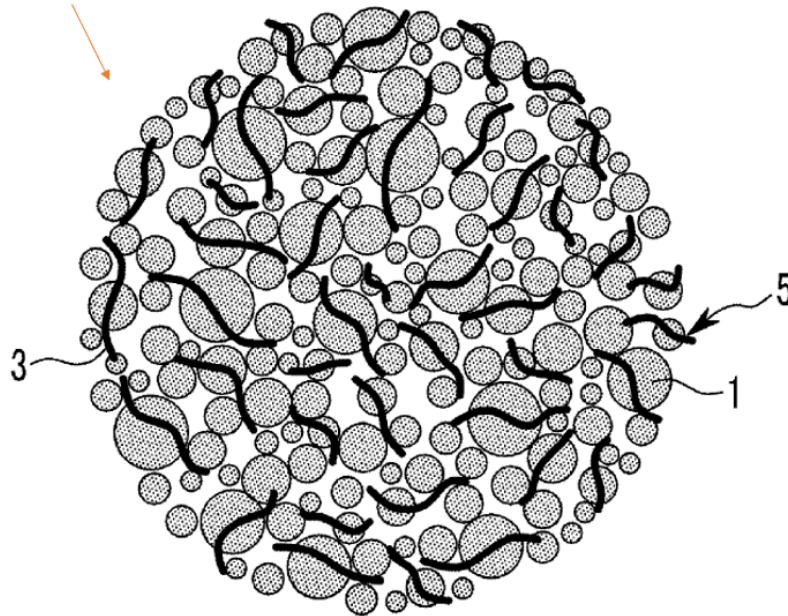
To the extent the preamble is deemed to be limiting, Lee-Wepasnick renders it obvious. LGES-1003, ¶¶153-160.

In the combination, an anode active material based on Lee is a composition

Lee-Wepasnick renders obvious a **composition** based on Lee's "anode active material." LGES-1006, Abstract; *see* [0003], [0010]-[0016], FIG. 1 (*infra*); LGES-1003, ¶154.

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Lee-Wepasnick
"composition"



Lee, FIG. 1 (annotated)

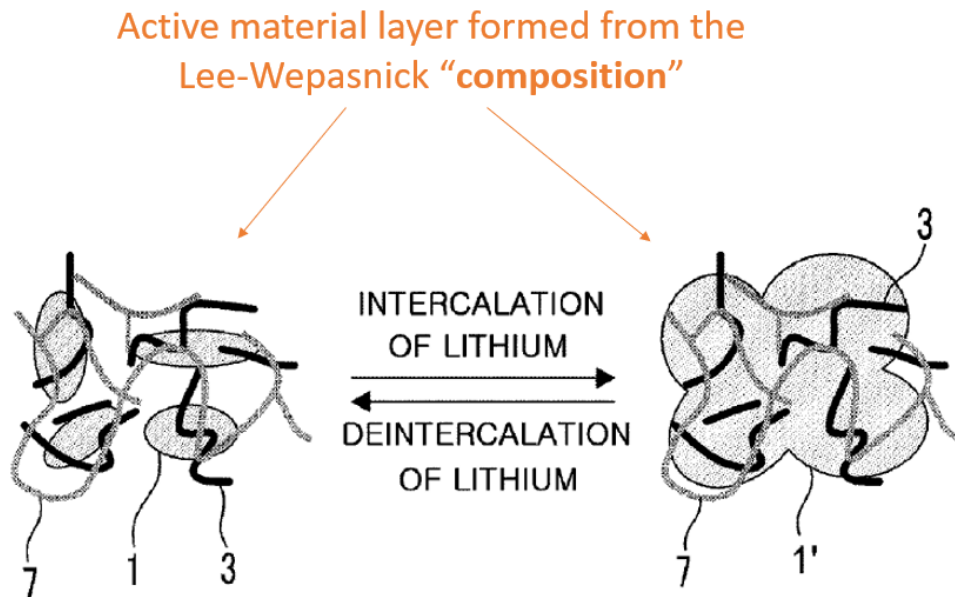
The combination **composition** includes “secondary particles that include agglomerated primary nanoparticles, wherein the primary nanoparticles include a non-carbonaceous material that is bound to hollow carbon nanofibers,” forming “a composite material.” *Id.*, [0014], [0043]; *see* [0060], FIG. 4, [0084], [0015]-[0016], [0039]-[0040], [0063], [0087], claim 1, claim 6, claim 12; LGES-1003, ¶155.

The hollow carbon nanofibers (*e.g.*, carbon nanotubes (*see* [1a], *infra*)) in the combination anode active material are oxidized based on Wepasnick, as discussed in [1d], *infra*. LGES-1003, ¶156.

In the combination, an anode active material composition based on Lee is a composition

Alternatively/additionally, Lee-Wepasnick renders obvious a **composition** based on Lee's "anode active material composition." LGES-1006, [0016]; LGES-1003, ¶157. This combination anode active material composition includes "the anode active material" discussed *supra*, "a binder, and a solvent." LGES-1006, [0016]; *see* [0064], FIG. 4, [0085], claim 12, claim 18; LGES-1003, ¶157.

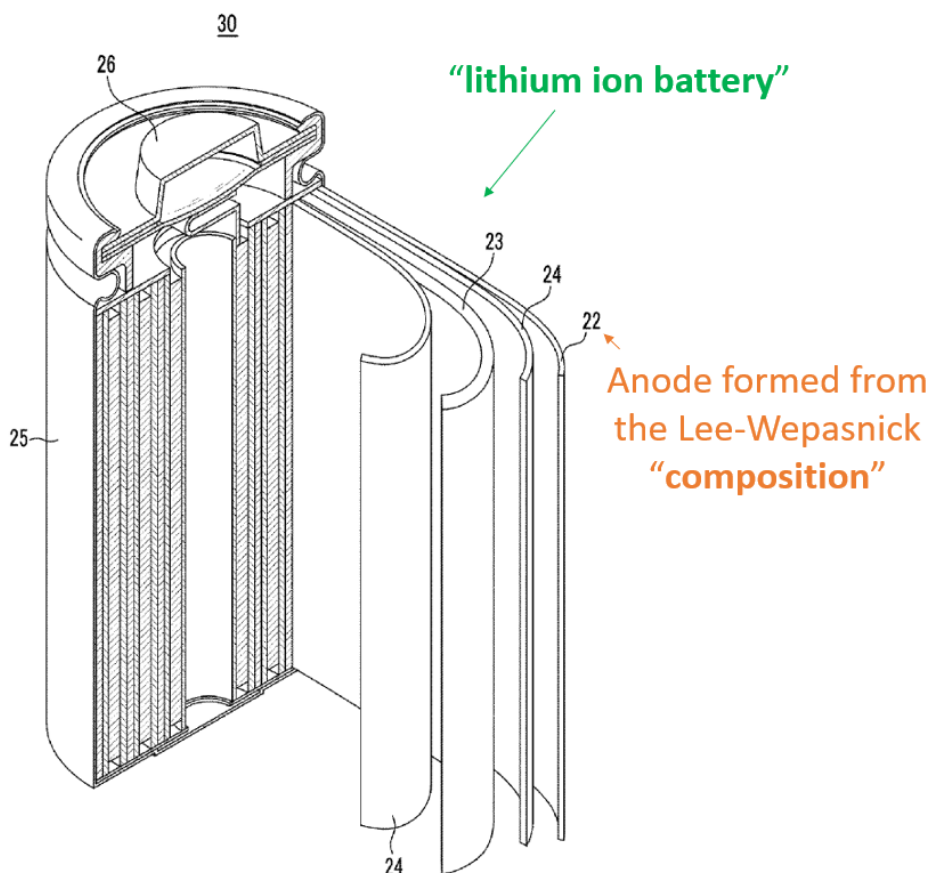
The combination anode active material composition can be coated onto a current collector, resulting in "an active material layer ... formed on the current collector." *Id.*, [0049]; *see* [0003], [0016], [0065], [0086]-[0087], claim 6, claim 12, FIG. 2. Lee's FIG. 3, *infra*, illustrates "the structure of the active material layer." *Id.*, [0051]; *see* [0054]; LGES-1003, ¶158.



Lee, FIG. 3 (annotated)

The combination composition is useful for lithium ion batteries

The Lee-Wepasnick composition (*e.g.*, either the anode active material or the anode active material composition) is **useful for lithium ion batteries**, as described by Lee. LGES-1003, ¶159. Specifically, based on Lee, the combination anode active material (**the composition**) is incorporated into an anode active material composition (alternatively/additionally **the composition**), which is “coated onto a current collector ... to manufacture an anode.” *Id.*, [0065]; *see* [0011] (“*an anode including the anode active material*”), [0058], [0003], [0016], [0049], [0086], claim 6, claim 12, FIG. 2. The anode (and thus the anode active material and anode active material composition) is an anode of **a lithium ion battery**. *See* LGES-1006, [0013] (“*a lithium battery including the anode*”), [0051], [0003], [0013], [0017], [0027], [0067], [0076], [0079], [0098], Abstract, claim 17, FIG. 5, *infra*; LGES-1003, ¶¶159-160.



Lee, FIG. 5 (annotated)

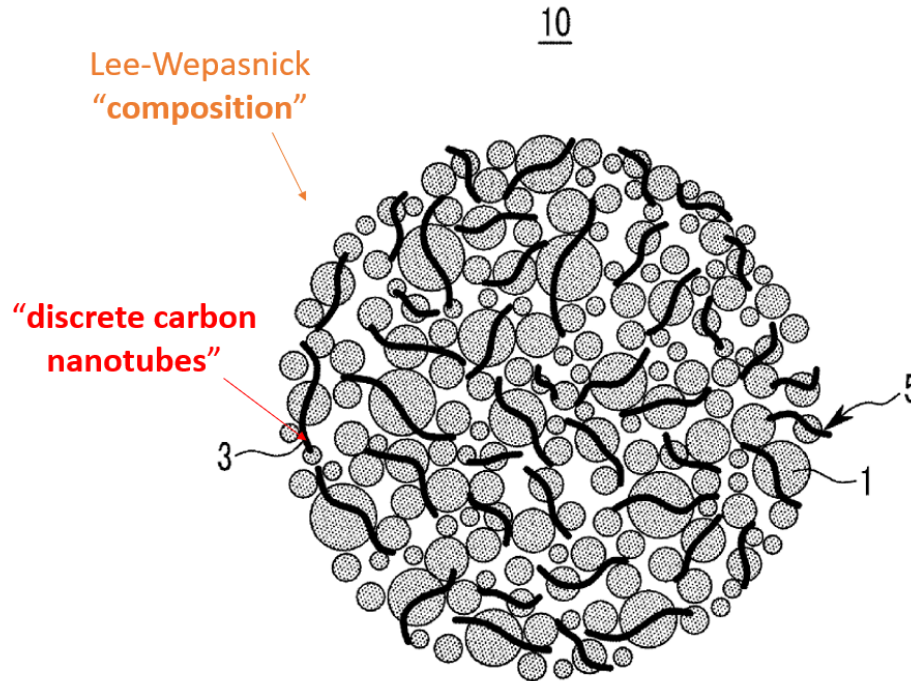
[1a]

The combination anode active material includes discrete carbon nanotubes

The combination **composition** (based on Lee's anode active material; see [1pre]) includes "secondary particles that are formed by the agglomeration of primary nanoparticles 5." LGES-1006, [0040]. The primary nanoparticles in turn "include a non-carbonaceous material 1 and *hollow carbon nanofibers* 3." LGES-1006, [0040]. The hollow carbon nanofibers, red in FIG. 1, *infra*, are "*carbon nanotubes*," *i.e.*, the combination anode active material (the **composition**) includes

carbon nanotubes. *Id.*, [0046]; *see* [0020], [0084], Abstract, [0014], [0087],

[0104]-[0105], claims 4 and 8; LGES-1003, ¶161.



Lee, FIG. 1 (annotated)

As illustrated in Lee's FIG. 1, the carbon nanotubes in the combination anode active material (the **composition**) are **discrete**, *e.g.*, to the extent that discrete in this context is interpreted as referring to nanotubes present in the anode active material as generally individually distinct (*e.g.*, non-agglomerated) nanotubes.⁸ LGES-1003, ¶162.

⁸ Lee fabricates its anode active material by mixing the non-carbonaceous material and nanotubes "using a milling process," such as "bead milling or ball milling."

Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidization of nanotubes can help promote non-agglomeration of the nanotubes. *See* [1d], *infra*; LGES-1003, ¶163. A POSITA would have known that oxidized nanotubes are functionalized by species such as carboxylic acid or hydroxyl groups. *See* LGES-1010, Abstract; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1007, [0027]-[0028]; LGES-1003, ¶163. As indicated by these references and as described by Dr. Zhu, the presence of these functionalities can contribute to physically and chemically inhibiting aggregation of nanotubes into clumps; instead, oxidized nanotubes generally can be present as individually distinct nanotubes. LGES-1003, ¶163. In light of this behavior of oxidized nanotubes, a POSITA would have understood or found obvious that oxidized nanotubes of the combination can be present as generally individually distinct nanotubes, *e.g.*, that the nanotubes are **discrete**. LGES-1003, ¶163.

LGES-1006, [0060]. At least some of the accused products are fabricated using a ball milling process. *See* LGES-1050. To the extent milling is compatible with discrete carbon nanotubes (which Petitioner does not necessarily concede), Lee's milling process (*e.g.*, as applied to the Lee-Wepasnick combination) is likewise consistent with discrete nanotubes. LGES-1003, ¶162.

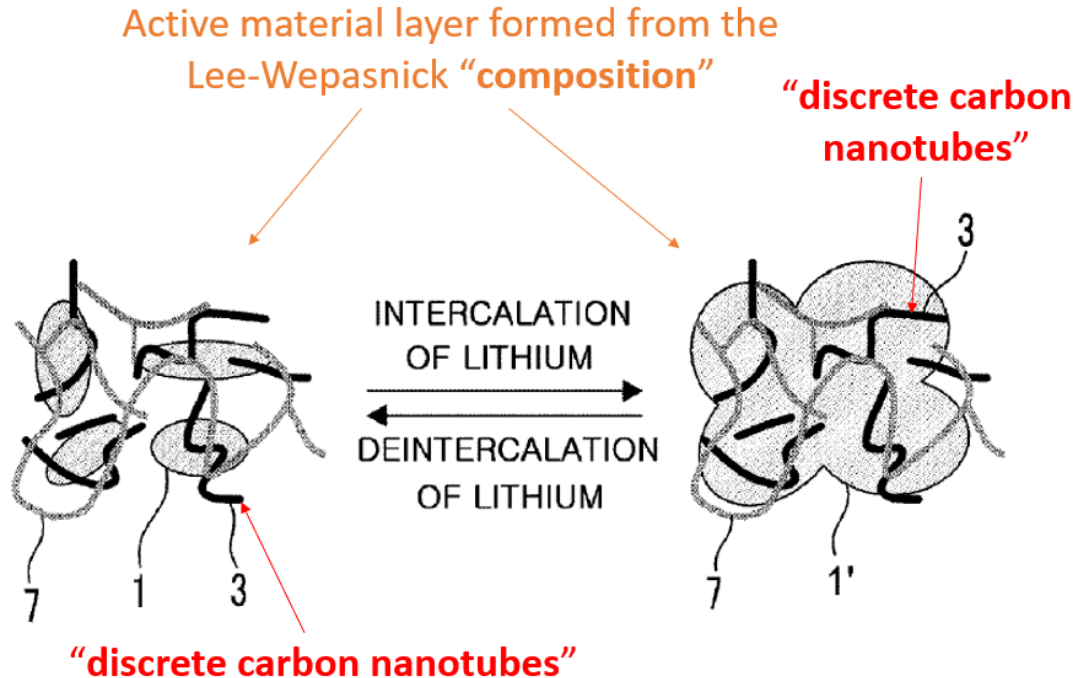
The combination anode active material composition includes discrete carbon nanotubes

Alternatively/additionally, the combination **composition** (based on Lee's anode active material composition; *see* [1pre]) also includes **carbon nanotubes**.

LGES-1003, ¶164. The anode active material composition includes the anode active material, which itself includes carbon nanotubes, as discussed *supra*. *See* LGES-1006, [0064]-[0065], [0016], [0084]-[0085], claim 12; LGES-1003, ¶164.

Lee explicitly confirms presence of hollow carbon nanofibers (**carbon nanotubes**) in the anode active material composition: “An anode electrode material composition comprising: secondary particles comprising agglomerated primary nanoparticles, the primary nanoparticles comprising *hollow carbon fibers*.” *Id.*, claim 18; *see* [0064], [0083]-[0085], claim 18 LGES-1003, ¶165.

The combination anode active material composition can be coated onto a current collector, resulting in “an active material layer ... formed on the current collector.” LGES-1006, [0049]; *see* [0016], [0057], [0065], [0086]-[0087]. Thus, composition of the combination active material layer is indicative of composition of the combination anode active material composition. LGES-1003, ¶166. Lee's FIG. 3, *infra*, which illustrates “the structure of the active material layer,” demonstrates inclusion of **carbon nanotubes** (red) in the anode active material composition. *Id.*, [0050]; *see* [0015], [0054], [0053].



Lee, FIG. 3 (annotated)

The combination active material layer (the **composition**) includes the anode active material, and thus the nanotubes in the combination active material layer are **discrete** for at least the reasons for which the nanotubes in the anode active material, as discussed *supra*. LGES-1003, ¶167.

Alternatively/additionally, the nanotubes in the combination anode active material composition are **discrete** based on Lee’s teaching that “[t]he electron donor group” of the polymer binder in the anode active material composition “aids the *dispersal of the hollow carbon nanofibers*.” LGES-1006, [0053]; LGES-1003, ¶168. That is, the nanotubes are generally dispersed as individual nanotubes.

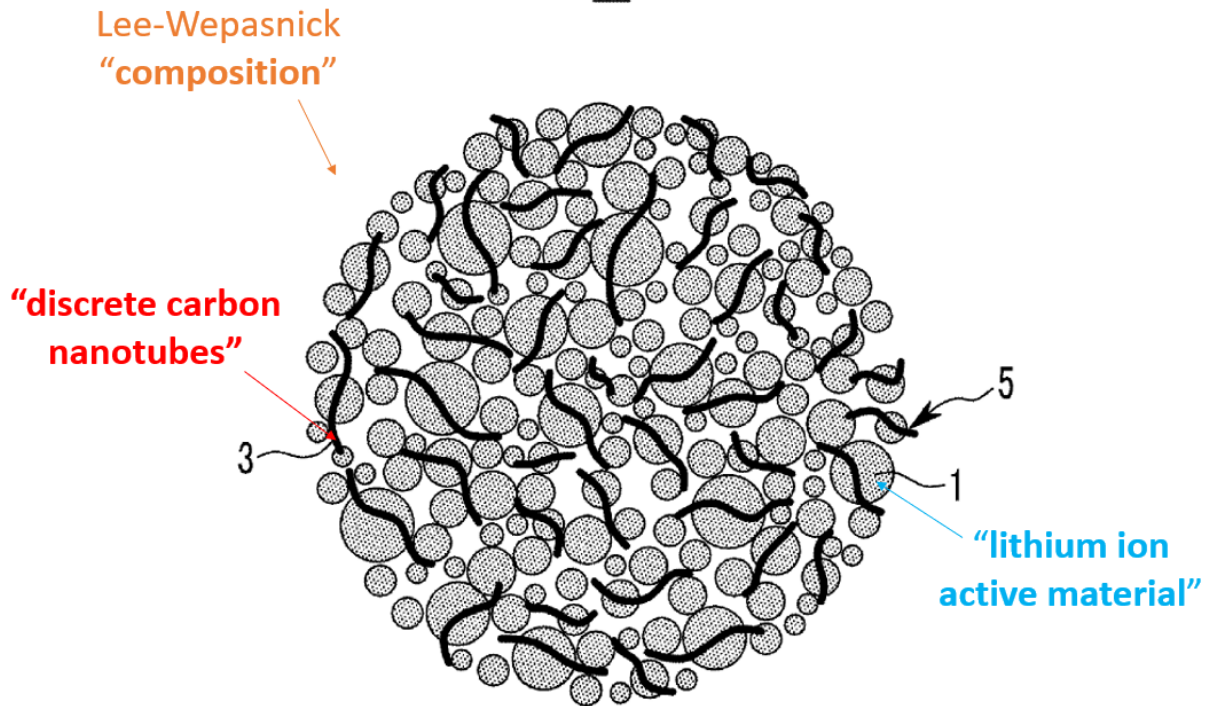
LGES-1003, ¶168; *see also* Lee's FIG. 3 schematic illustration of **discrete** nanotubes. LGES-1003, ¶168.

[1b]

The combination anode active material includes lithium ion active material attached to the surface of the nanotubes

The Lee-Wepasnick **composition** (based on Lee's anode active material; *see* [1pre]) includes "secondary particles that are formed by the agglomeration of primary nanoparticles 5, which in turn "include a ***non-carbonaceous material*** 1 and hollow carbon nanofibers." *Id.* The non-carbonaceous material, blue *infra*, corresponds to a **lithium ion active material**. LGES-1006, [0040]; *see* LGES-1006, Abstract, [0018], [0039], [0043]-[0044], [0063], [0084], [0014], [0041], claims 1-3, claim 5-6, claims 11-12, claims 18-19; LGES-1003, ¶169;

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Lee, FIG. 1 (annotated)

This combination non-carbonaceous material is a **lithium ion active material**, *e.g.*, because it is capable of intercalation/deintercalation of lithium ions. LGES-1003, ¶170. For instance, Lee describes that “the volume of the non-carbonaceous material 1 changes, due to the *intercalation/de-intercalation [of] lithium.*” LGES-1006, [0053]; *see* [0042]-[0043], [0006]-[0007] (“non-carbonaceous materials, such as silicon (Si), are being studied for use as *anode active materials*”), [0051], FIG. 3. Moreover, the specific non-carbonaceous materials identified by Lee (a material “selected from the group consisting of silicon (Si), a silicon oxide ((SiO_x) where 0 ≤ x ≤ 2)), Si—Y, and a mixture thereof. Y may be As, Sb, Bi, Cu, Ni, Mg, In, Zn, Ag, Al, or a combination thereof”) are

examples of conventional **lithium ion active materials**. LGES-1006, [0018]; LGES-1003, ¶170 (citing LGES-1035, [0004]).

In the combination, as described by Lee, the **lithium ion active material** (*e.g.*, based on Lee's non-carbonaceous material) is **attached to the surface of the nanotubes**, *e.g.*, by Van der Waals forces: "the hollow carbon nanofibers ... are **bound** to the non-carbonaceous material *by Van der Waals forces*." LGES-1006, [0040]; *see* [0043], [0044], [0063], [0084], [0014]-[0016], [0039], [0101], Abstract, claim 1, claim 6; LGES-1003, ¶¶171-173.

Alternatively/additionally, a POSITA also would have recognized that the presence of oxygen-containing functional groups (*see* [1d]) facilitates the attachment of the lithium ion active material to the nanotube surface. LGES-1003, ¶174 (citing LGES-1010, 2). The **attachment** can be a covalent bond between functional groups on the nanotubes and the non-carbonaceous material (*i.e.*, the lithium ion active material). LGES-1003, ¶174 (citing LGES-1043, 2-3).

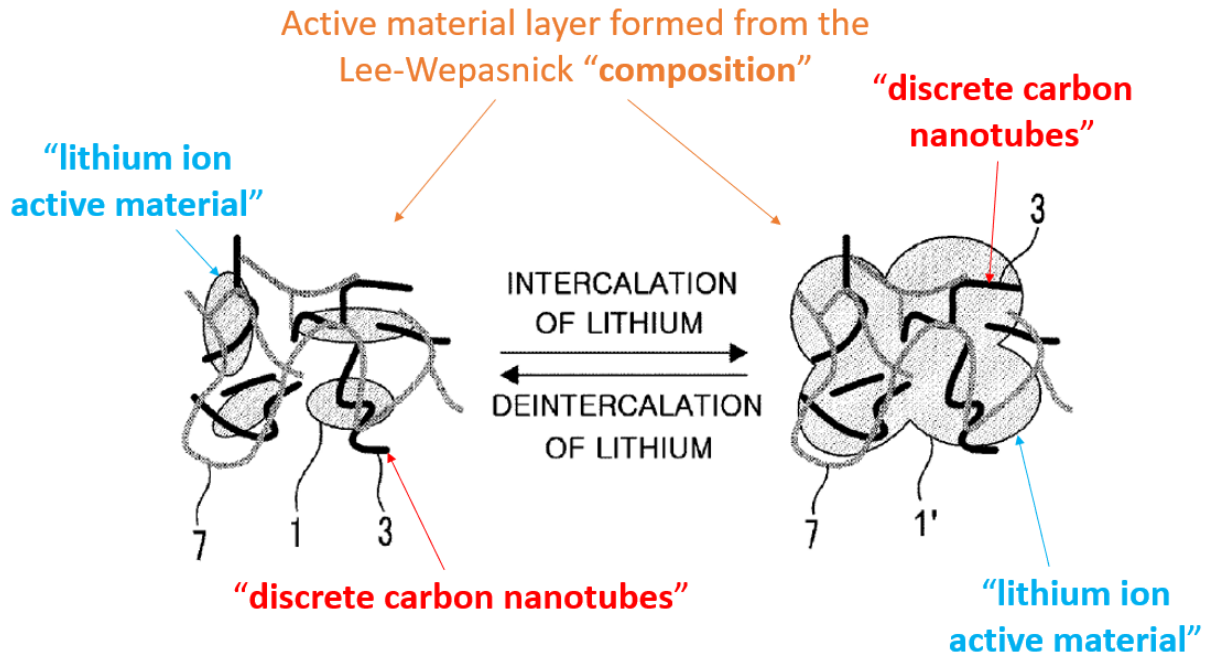
Moreover, there is hydrogen bonding between the non-carbonaceous materials and the functional groups on the nanotube surfaces; to the extent this is considered an attachment, the non-carbonaceous material is alternatively/additionally **attached** to the nanotubes through hydrogen bonding. LGES-1003, ¶175.

The combination anode active material composition includes lithium ion active material attached to the surface of the nanotubes

Alternatively/additionally, the Lee-Wepasnick composition (based on Lee's anode active material composition; *see* [1pre]) includes **lithium ion active material attached to the surface of the nanotubes**. This is the case at least because the anode active material composition includes the anode active material, which itself includes lithium ion active material attached to the surface of the nanotubes, discussed *supra*. *See* LGES-1006, [0064]-[0065] (“the anode active material and the polymeric binder are mixed in a solvent, to prepare an anode active material composition”), [0016], [0084]-[0085], claim 12. And Lee's discussion of the composition of the anode active material composition confirms presence of non-carbonaceous material (**lithium ion active material**): *see* [0083]-[0085], claim 18 (“An anode electrode material composition ... hollow carbon fibers attached to *a silicon-based material*”); LGES-1003, ¶176.

The composition of the combination active material layer is indicative of the that of the combination anode active material composition. *See* LGES-1006, [0016]. [0049], [0057], [0065], [0086]-[0087]. Lee's FIG. 3, *infra*, illustrating “the structure of the active material layer,” demonstrates that the anode active material composition includes “non-carbonaceous material 1” (blue), *e.g.*, **lithium ion active material**. *Id.*, [0053]; *see* [0015], [0051] (“reference number 1' denotes a

composite of Li and the *non-carbonaceous material 1*, which is generated during charging of the anode 20”); LGES-1003, ¶177.



Lee, FIG. 3 (annotated)

The combination composition includes crystals of lithium ion active material

In the combination composition (based on either Lee’s anode active material or Lee’s anode active material composition), a POSITA would have understood, or at least found obvious, that the lithium ion active material (*e.g.*, the non-carbonaceous material) is in the form of **crystals**. LGES-1003, ¶¶178-188.

Lee identifies silicon as an example of a non-carbonaceous material (*see* Lee, [0041]), and further specifies that silicon as an active material in an anode has a “*crystalline lattice*,” *i.e.*, the particles of silicon non-carbonaceous material (**lithium ion active material**) are **crystals**. *Id.*, [0059]; LGES-1003, ¶179.

Lee notes that in “conventional anodes,” crystalline silicon can be problematic, *e.g.*, because “abrupt volumetric changes in the crystalline lattice” can occur, “thereby fracturing the conventional active material.” LGES-1006, [0059]. However, Lee’s anode active material composition is structured to “enhance the cohesion of [the] anode,” thus mitigating these problems with conventional use of crystalline silicon. *Id.*, [0058]; *see* [0059]; LGES-1003, ¶180. Given this context, a POSITA would have understood Lee’s disclosure as describing, and consistent with, the use of **crystals** of lithium ion active material. LGES-1003, ¶180.

Alternatively/additionally, to the extent that Lee does not specifically state that the silicon/silicon-metal alloy in the anode active material are **crystals or layers**, a POSITA would have found this to be obvious. LGES-1003, ¶181.

First, Lee’s “method of manufacturing the anode” involves mixing “a non-carbonaceous material” [*i.e.*, the lithium ion active material] “and hollow carbon nanofibers ... using a milling process” such as “bead milling or a ball milling.” LGES-1006, [0060]. A POSITA would have recognized that ball milling produces crystals, *e.g.*, polycrystalline or nanocrystalline material.⁹ LGES-1003, ¶182 (citing LGES-1025, Abstract; LGES-1026, Abstract; LGES-1027, 20:30-33).

⁹ The ’909 Patent describes a similar manufacturing process: “Lithium iron phosphate ... is ground with multiwall carbon nanotubes ... in a mortar and

Second, crystals of lithium ion active materials have performance advantages, *e.g.*, higher electrical conductivity, faster lithiation rate. LGES-1003, ¶183 (citing LGES-1028, 19:24-27; LGES-1029, 4:36-39, 3:59-4:2).

Third, the use of crystals of lithium ion active material was obvious to try. It is one of a finite number of known solutions—namely, either crystals or amorphous material. LGES-1003, ¶184. It was predictable: behavior of silicon and silicon-metal alloy crystals as lithium ion active material was conventional and well-characterized as of the Critical Date. LGES-1003, ¶184 (citing LGES-1035, [0004]). And a POSITA would have had a reasonable expectation of success, discussed *infra*. LGES-1003, ¶184; *see KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 415-421, 82 USPQ2d 1385, 1395-97 (2007).

Fourth, this implementation is merely application of known techniques (crystals of a lithium ion active material) to a known structure (the Lee-Wepasnick anode active material) to yield predictable results (an anode active material

pestle.” LGES-1001, 5:53-57. To the extent that this disclosure is consistent with existence of **crystals** of lithium iron phosphate attached to the surface of the nanotubes, a POSITA would have recognized Lee’s similar disclosure as also consistent with the **crystals** of lithium ion active material. LGES-1003, ¶182.

containing crystals of lithium ion active material). LGES-1003, ¶185; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in using crystals of lithium ion active material. LGES-1003, ¶186.

First, Lee indicates that challenges involved in using crystals of lithium ion active material can be overcome through the structure of its anode active material composition. *See* LGES-1006, [0058]-[0059]; LGES-1003, ¶187.

Second, the use of crystals of lithium ion active material was well-characterized, and a POSITA would have known how to structure crystals of lithium ion active material to achieve advantages of the crystallinity. LGES-1003, ¶188.

[1c]

The carbon nanotubes in the combination “have *an aspect ratio of about 10 to about 10,000*,” as taught by Lee. LGES-1006, [0047]; LGES-1003, ¶¶189-192 (citing LGES-1039, Abstract).

The claimed range of aspect ratios (**10-500**) overlaps with the range of aspect ratios (**10-10,000**) described by Lee and implemented in Lee-Wepasnick. LGES-1003, ¶190. The '909 Patent provides no discussion or evidence of unexpected results or criticality associated with nanotubes having an aspect ratio within the claimed range. Thus, based on the overlapping range disclosed by Lee,

Lee-Wepasnick presents a *prima facie* case and renders obvious the recited range of aspect ratios. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

[1d]

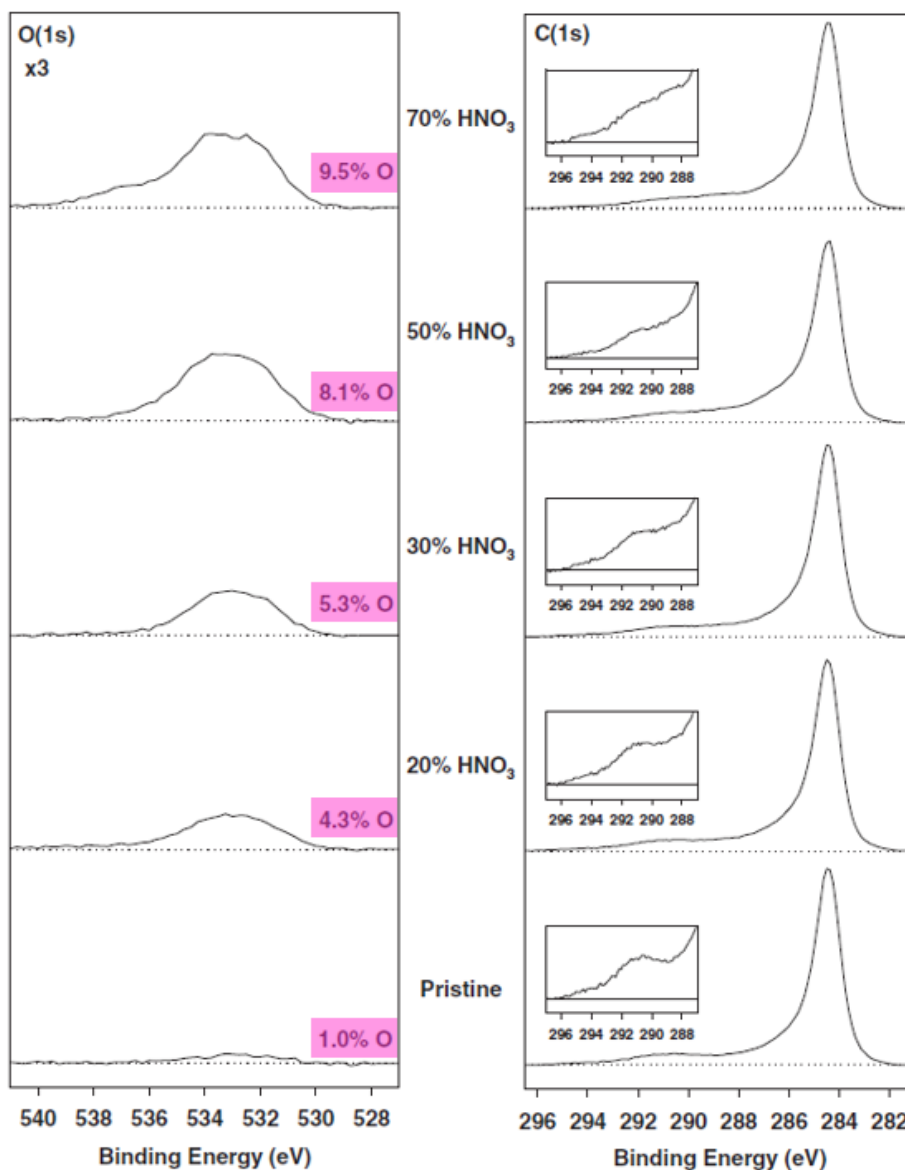
The carbon nanotubes in the combination composition are **oxidized** based on Wepasnick. LGES-1003, ¶193. For instance, the nanotubes are oxidized in a “commonly used wet chemical oxidant[,]” producing “carboxyl, carbonyl, and hydroxyl groups” on the nanotubes. LGES-1010, Abstract; *see* 2, 2, 2; LGES-1003, ¶193.

As explained by Dr. Zhu, nanotube oxidation levels can be characterized using various experimental techniques, and the results of those measurements can be converted to oxidation levels by weight using at least two conversion techniques. LGES-1003, ¶¶14-17. Oxidation levels of the nanotubes in the Lee-Wepasnick combination render obvious the claimed range of oxidation levels when measured by each of multiple of these experimental techniques, and when each of these conversion approaches is applied, as discussed here. LGES-1003, ¶¶194-210.

Nanotubes oxidized using HNO₃ have oxidation levels within the claimed range

In one example, the nanotubes in the combination are oxidized using HNO₃, based on Wepasnick. *See* LGES-1010, 3; LGES-1003, ¶194. By varying “the

w/w% HNO_3 (from 0-70%), “the extent of MWCNT oxidation” (highlighted in Fig. 6, *infra*) can be controlled between 4.3 at.% and 9.5 at.%, as measured by one experimental technique, X-ray photoelectron spectroscopy (XPS). See LGES-1010, 7; LGES-1003, ¶194.



Wepasnick, Fig. 6 (annotated)

The oxidation levels by weight of the nanotubes indicated by Wepasnick's

Fig. 6 measurements are summarized in Table 1, *infra*. LGES-1003, ¶¶195-200.

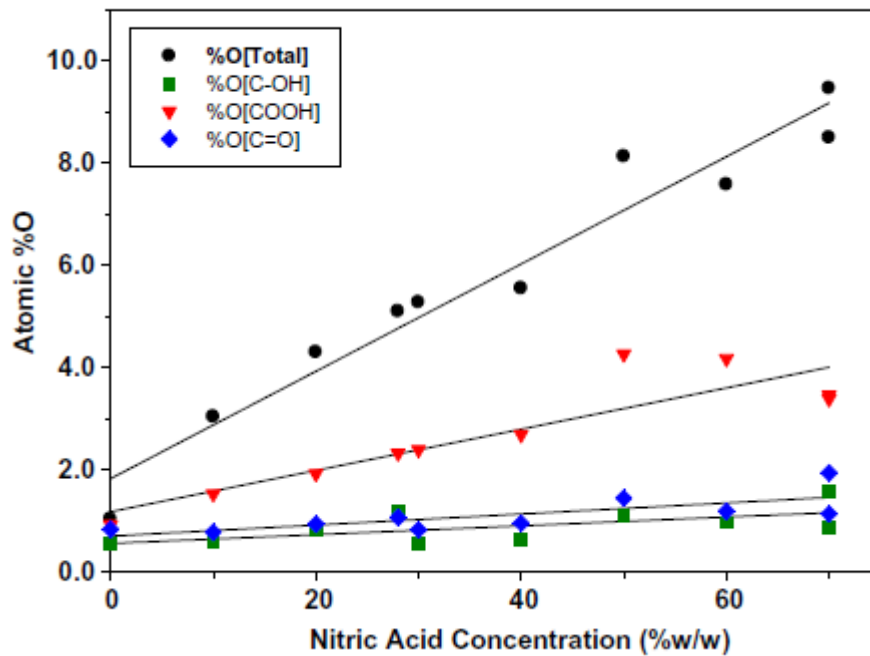
HNO ₃	at.% oxygen	Oxidation level (wt.% oxygen)	Oxidation level (wt.% functional groups)
20%	4.3 at.%	5.7 wt.%	7.4 wt. %
30%	5.3 at.%	6.9 wt.%	7.7 wt. %
50%	8.1 at.%	10.5 wt.%	13.8 wt. %
70%	9.5 at.%	12.3 wt.%	14.6 wt. %

Table 1. Oxidation levels of Wepasnick's HNO₃-oxidized nanotubes. *See*

LGES-1010, Figs. 6-7; LGES-1003, ¶195. As explained by Dr. Zhu, one reasonable and well-known way that the **oxidation levels by weight of the nanotubes** can be determined is by calculating weight of the oxygen atoms attached to the nanotubes divided by total weight of the oxidized nanotubes, and a POSITA would have recognized this approach as applicable to nanotubes such as those disclosed by Wepasnick (although there are other approaches). LGES-1003, ¶¶14-17, 195. Based on this method, the specific oxidation levels for Wepasnick's HNO₃-oxidized nanotubes correspond to values ranging from **5.7% to 12.3% by weight** of the carbon nanotube (blue and bold in Table 1, *supra*). LGES-1003, ¶195. Each of these calculated oxidation levels for Wepasnick's HNO₃-oxidized nanotubes falls within the recited range of oxidation levels (**1% to 15% by weight**). LGES-1003, ¶196. Thus, Wepasnick's HNO₃-oxidized nanotubes, applied to the Lee-

Wepasnick combination, constitute a relevant disclosure for the recited range of oxidation levels: Lee-Wepasnick renders obvious a composition having nanotubes with **oxidation levels from 1% to 15% by weight**. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782.

Wepasnick also demonstrates that “varying the w/w% of HNO₃” affects “the distribution of hydroxyl, carbonyl and carboxylic acid groups.” LGES-1010, 7; *see* Fig. 7, *infra*; LGES-1003, ¶197. This distribution of functional species can be used to calculate the weight percentage of functional groups attached to the nanotubes divided by the total weight of the oxidized nanotubes. LGES-1003, ¶¶14-17, 198. A POSITA alternatively/additionally would have recognized this approach as another reasonable and well-known way to determine oxidation levels by weight for nanotubes such as Wepasnick’s. LGES-1003, ¶198. Based on this method, the specific oxidation levels described by Wepasnick for nanotubes oxidized with 20%, 30%, and 50% HNO₃ correspond to oxidation levels of **7.4%, 7.7%, 13.8%, and 14.6% by weight** of the carbon nanotube, respectively (green italics in Table 1, *supra*). LGES-1003, ¶199.



Wepasnick, Fig. 7

These values (7.4%, 7.7%, 13.8%, and 14.6% by weight) fall within the recited range of oxidation levels (1% to 15% by weight). LGES-1003, ¶200.

Thus, the oxidation levels of these three types of HNO₃-oxidized nanotubes, applied to the Lee-Wepasnick nanotubes, constitute a relevant disclosure for the recited range of oxidation levels: Lee-Wepasnick renders obvious a composition having nanotubes with **oxidation levels from 1% to 15% by weight**. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

Nanotubes oxidized to 4.5-5.5 atomic percent have oxidation levels within the claimed range

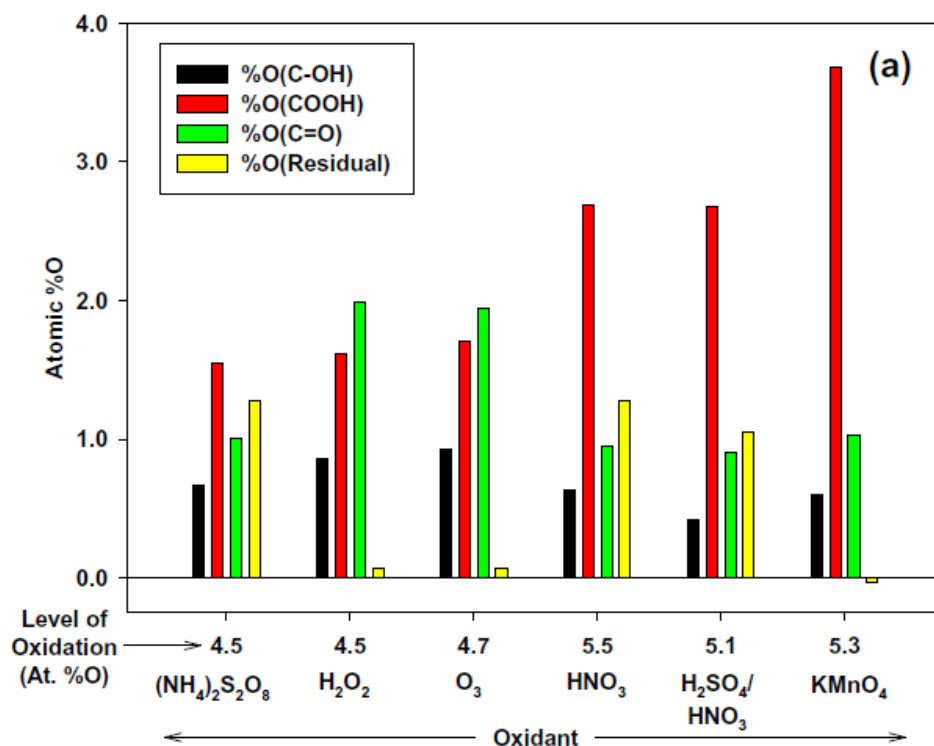
Alternatively/additionally, the nanotubes in the combination composition are oxidized to an “overall level of oxidation” of “4.5-5.5 at. % O,” again as measured

by XPS characterization as taught by Wepasnick, using an oxidant selected from a list of common oxidants. LGES-1010, 8, Fig. 9; LGES-1003, ¶201.

When the **oxidation level by weight of the nanotubes** is determined by calculating weight of the oxygen atoms attached to the nanotubes divided by total weight of the oxidized nanotubes (*see* LGES-1003, ¶¶14-17), the specific example of Wepasnick's nanotubes oxidized to 4.5-5.5 at.% oxygen corresponds to an **oxidation level by weight of 5.9-7.2% by weight**. LGES-1003, ¶202.

This range of oxidation levels falls within the recited range of oxidation levels (**1% to 15% by weight**). LGES-1003, ¶203. Thus, this range of oxidation levels, applied to the Lee-Wepasnick nanotubes, constitutes a relevant disclosure for the recited range of oxidation levels: Lee-Wepasnick renders obvious a composition having nanotubes with **oxidation levels from 1% to 15% by weight**. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782.

Wepasnick also demonstrates that “distribution of oxygen-containing functional groups is sensitive to the oxidant.” Wepasnick, 8; *see* Fig. 9(a), *infra*; LGES-1003, ¶204.



Wepasnick, Fig. 9(a)

This distribution of functional species can be used to calculate the weight percentage of functional groups, which is another reasonable way to approach calculation of the **oxidation level by weight of the nanotubes**. LGES-1003, ¶¶14-17, 205. Based on this method, the oxidation levels of the nanotubes represented in Wepasnick's Fig. 9(a) range from **6.5-10.1%** by weight of the carbon nanotube (red and bold in Table 2, *infra*). LGES-1003, ¶205. Alternatively/additionally, to the extent that residual oxygen is also considered as contributing to the oxidation levels of the nanotubes (which Petitioner does not necessarily concede), the oxidation levels of the nanotubes represented in Wepasnick's Fig. 9(a) range from **7.9-10.1%** by weight (shown in purple italics in Table 2, *infra*). LGES-1003, ¶205.

Oxidant	at.% oxygen	Oxidation level (without residual oxygen)	Oxidation level (with residual oxygen)
(NH ₄) ₂ S ₂ O ₈	4.5 at. %	6.5 wt. %	7.9 wt. %
H ₂ O ₂	4.5 at. %	9.7 wt. %	9.8 wt. %
O ₃	4.7 at. %	9.9 wt. %	10.0 wt. %
HNO ₃	5.5 at. %	8.0 wt. %	9.6 wt. %
H ₂ SO ₄ /HNO ₃	5.1 at. %	7.6 wt. %	8.9 wt. %
KMnO ₄	5.3 at. %	10.1 wt. %	10.1 wt. %

Table 2. Oxidation levels of Wepasnick's oxidized nanotubes. *See* LGES-1010, Fig. 9; LGES-1003, ¶205.

Each of the oxidation levels calculated based on Wepasnick's Fig. 9(a) and tabulated in Table 2, *supra*, falls within the recited range of oxidation levels (**1% to 15% by weight**). LGES-1003, ¶206. Thus, these oxidation levels, applied to the Lee-Wepasnick nanotubes, constitute a relevant disclosure for the recited range of oxidation levels: Lee-Wepasnick renders obvious a composition having nanotubes with **oxidation levels from 1% to 15% by weight**. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782.

Wepasnick's EDX results corroborate the XPS results used to determine oxidation levels

The oxidation levels discussed *supra* are based on Wepasnick's XPS measurements of atomic oxygen concentration. *See* LGES-1010, Figs. 5-9. While the '909 Patent does not identify a specific characterization technique to be used

for determining oxidation levels, a POSITA would have recognized XPS as a reasonable way to determine oxidation levels for nanotubes such as Wepasnick's. *See* LGES-1005, 4; LGES-1009, 4; LGES-1003, ¶¶14-17, 207-210.

Nevertheless, other experimental techniques are available for measuring oxidation levels. LGES-1003, ¶¶14-17, 207-210. Wepasnick also EDX¹⁰ “to quantify the atomic oxygen concentration.” LGES-1010, 6; LGES-1003, ¶208. Dr. Zhu explains that a POSITA would have understood that, in the context of Wepasnick's nanotubes, both Wepasnick's XPS and EDX data can indicate oxidation levels (although still other techniques may be more appropriate in some circumstances). LGES-1003, ¶28. Wepasnick's Fig. 5 EDX data show that the nanotubes discussed *supra* (which have oxidation levels falling within the claimed range as determined by XPS) generally also have oxidation levels falling within the claimed range as determined by EDX, thus alternatively/additionally rendering obvious the claimed range. LGES-1003, ¶¶209-210.

(ii) Claim 2

In Lee-Wepasnick, the anode active material and/or anode active material composition (the **composition**; *see* [1pre]) includes “non-carbonaceous material” (**lithium ion active material**) which “can be selected from the group consisting of

¹⁰ Energy dispersive X-ray spectroscopy. *See* LGES-1010, 3.

silicon (Si), a silicon oxide ((SiO_x) where 0 ≤ x ≤ 2)), Si—Y₂ and a mixture thereof.

Y may be As, **Sb**, Bi, **Cu**, Ni, Mg, In, Zn, Ag, **Al**, or a combination thereof,” *i.e.*,

the **lithium ion active material comprises silicon, copper, antimony, and/or**

aluminum. LGES-1006, [0018]; *see* [0084], claims 5, 11, 19; LGES-1003, ¶211.

(iii) Claim 5

The ratio of carbon nanotubes to lithium ion active material in the combination is based on Lee. LGES-1003, ¶212.

In Example 1, Lee describes that “the proportions of the anode active material, the conducting agent and the binder were 55% (**50% of Si and 5% of carbon nanotubes, by weight**), 30%, and 15%, respectively, by weight.” LGES-1006, [0085]. The composition of this example corresponds to the carbon nanotubes being present in a weight percentage of **10% by weight** of the lithium ion active material. LGES-1003, ¶213. Alternatively/additionally, to the extent the weight percentage is based on the total weight of both nanotubes and lithium ion active material, the Example 1 composition corresponds to the carbon nanotubes being present in a weight percentage of **9.1% by weight** (5 parts nanotubes per 55 parts total). LGES-1003, ¶213.

In Example 2, Lee describes that “no conducting agent was used, and the proportions of the anode active material and the binder were 85% by weight (**76.5% by weight of Si and 8.5% by weight of carbon nanotubes**) and 15% by

weight, respectively.” *Id.*, [0087]. In this example, to the extent the weight percentage is based on the total weight of both nanotubes and lithium ion active material, the carbon nanotubes are present in a weight percentage of **10% by weight** (8.5 parts nanotubes per 85 parts total). LGES-1003, ¶214.

These specific examples of weight percentages (**9.1% and 10%**) fall within the claimed **0.1% to 10%** range of weight percentages. LGES-1003, ¶215. As such, in Lee-Wepasnick, these specific weight percentages disclosed by Lee are relevant disclosures for the recited range of weight percentages, and Lee-Wepasnick thus renders obvious the claimed range of weight percentages. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

Alternatively/additionally, in the combination, Lee describes that “[i]n the anode active material 10, a mixing ratio of the non-carbonaceous material 1 to the hollow carbon nanofibers 3 may be in **a range of about 2:1 to about 50:1, by weight**, and particularly, about 5:1 to about 10:1, by weight.” LGES-1006, [0048]. The 2:1-50:1 range of ratios corresponds to a range of weight percentages of **2% to 50%** (or **2% to 33%**, to the extent the weight percentage is based on the total weight of both nanotubes and lithium ion active material). The 5:1 to 10:1 range of ratios corresponds to a range of weight percentages of 10% to 20% (or **9% to 17%**, to the extent the weight percentage is based on the total weight of both

nanotubes and lithium ion active material). *See also id.*, claims 3, 7, 16. LGES-1003, ¶216.

The claimed range of weight percentages (**0.1% to 10%**) overlaps with the range of weight percentages described by Lee (**2-50%** or **2-33%** or **9-17%**) and implemented in Lee-Wepasnick. LGES-1003, ¶217. The '909 Patent provides no discussion or evidence of unexpected results or criticality associated with nanotubes having an aspect ratio within the claimed range. Thus, based on the overlapping range disclosed by Lee, Lee-Wepasnick presents a *prima facie* case and renders obvious the recited range of weight percentages. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

(iv) Claim 6

[6a]

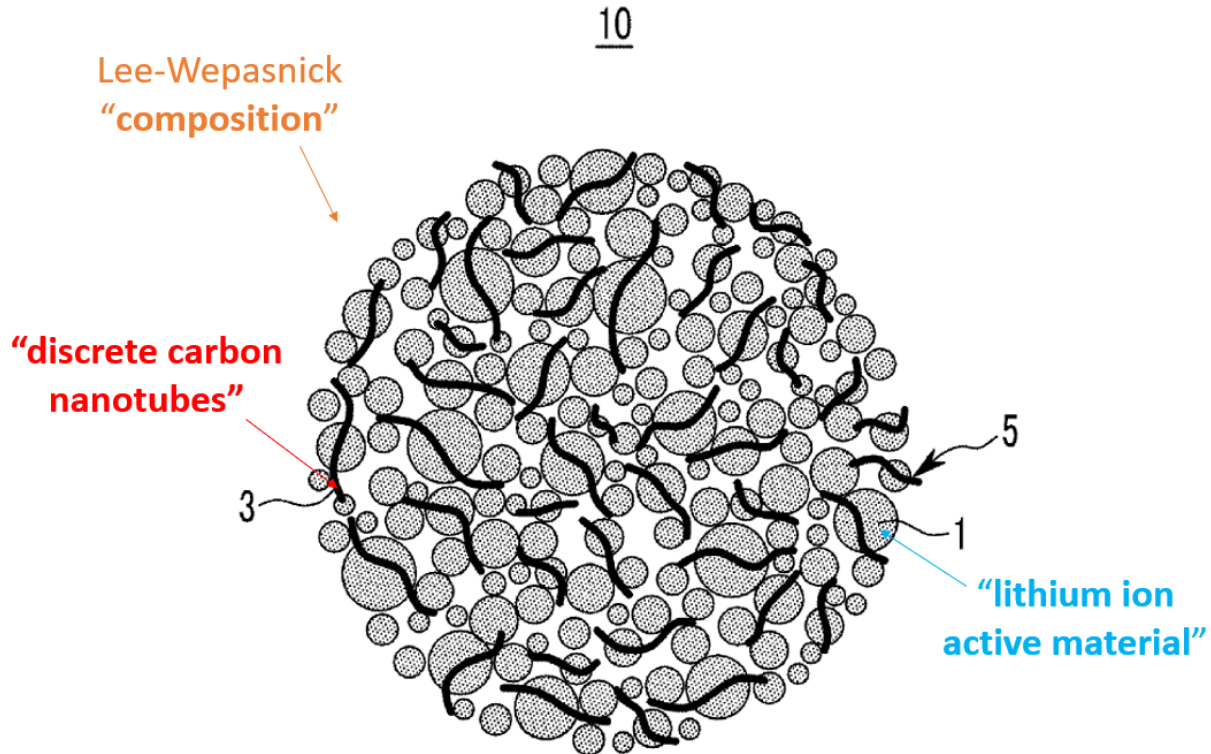
See [1b], [1d]; LGES-1003, ¶218.

[6b]

As discussed in [1a], the nanotubes in the combination anode active material (the **composition**) are present as generally individually distinct nanotubes, *e.g.*, they are **dispersed** in the composition. *See* [1a]; LGES-1003, ¶219. Based on Lee's FIG. 1, *infra*, which illustrates "the structure of an anode active material," and based on the dispersed nature of the nanotubes, a POSITA would have understood, or at least found obvious, that the nanotubes are **uniformly dispersed**

without clustering in the combination anode active material. LGES-1003, ¶219.

Thus, because there is substantially no clustering, a POSITA would have understood that the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. LGES-1003, ¶219.



Lee, FIG. 1 (annotated)

(v) **Claim 7**

The combination composition includes uniformly dispersed, oxidized carbon nanotubes having crystals or layers of lithium ion active materials attached to their surface. *See* [6], *supra*; LGES-1003, ¶220. Moreover, the nanotubes are **dispersible** because the combination composition is capable of being mixed. LGES-1003, ¶221. For instance, to form the anode active material (the

composition; *see* [1pre]), “a non-carbonaceous material and hollow carbon nanofibers are ***mixed*** in an organic solvent.” LGES-1006, [0060]. To form the anode active material composition (alternatively/additionally the **composition**; *see* [1pre]), “the anode active material and the polymeric binder are ***mixed*** in a solvent.” *Id.*, [0064]. Alternatively/additionally, the nanotubes are **dispersible** because they are not attached to a substrate. LGES-1003, ¶222.

(vi) **Claim 8**

In Lee-Wepasnick, a POSITA would have recognized that the presence of oxygen-containing functional groups (*see* [1d], *supra*) facilitates attachment of lithium ion active material to the nanotube surface, *e.g.*, via covalent bonds between the non-carbonaceous material (the lithium ion active material) and those oxygen-containing species. LGES-1003, ¶223 (citing LGES-1010, 2). The lithium ion active material is **chemically attached** to the surface of the nanotubes via these covalent bonds. *Id.*

Alternatively/additionally, the interaction between lithium ion active material and nanotubes can be via Van der Waals forces: “hollow carbon nanofibers ... are ***bound to the non-carbonaceous material by Van der Waals forces***.” LGES-1006, [0039]; *see* [0040], [0084], [0014]-[0016], [0043]-[0044], [0063], [0101], Abstract, claim 1, claim 6. To the extent that Van der Waals forces

can be considered a chemical attachment, the lithium ion active material is

chemically attached to the nanotube surface via these forces. LGES-1003, ¶224.

Still alternatively/additionally, the lithium ion active material is **chemically attached** to the nanotubes via hydrogen bonds. LGES-1003, ¶225.

C. [GROUND 2B] – CLAIMS 3 AND 4 ARE OBVIOUS OVER LEE-WEPASNICK-ZHAMU

The sections below provide an introduction to Zhamu and its combination with Lee-Wepasnick.¹¹

1. Zhamu describes anode active materials containing graphene

Zhamu describes a “nano graphene-enhanced particulate for use as a lithium-ion battery anode active material.” LGES-1008, Abstract. Zhamu’s particulates include “graphene sheets,” “fine anode active material particles,” and “a carbon or graphite material.” *Id.*, [0071]; *see* FIG. 3(B); LGES-1003, ¶¶226-227.

¹¹ Petitioner incorporates this discussion into Ground 2B.

2. The Lee-Wepasnick-Zhamu combination

Lee describes that the anode active material composition includes “[a] conducting agent,” implemented in Lee-Wepasnick-Zhamu as graphene based on Zhamu. LGES-1006, [0057]; LGES-1008, [0071]; LGES-1003, ¶228.

3. Reasons for the combination

A POSITA would have been motivated to implement the conducting agent in combination as graphene. LGES-1003, ¶229-234.

First, graphene as a conductive additive offers advantageous thermal management properties, which implicate battery performance. *See* LGES-1008, [0072], [0146]; LGES-1003, ¶230.

Second, graphene provides structural integrity to the composition, which is relevant in the context of Lee-Wepasnick, where “cohesion” of the composition is a focus. *See* LGES-1008, [0145], [0151]; LGES-1006, [0053]; LGES-1003, ¶231.

Third, graphene has desirable electrical conductivity properties. *See* LGES-1006, [0057]; LGES-1008, [0147]-[0148]; LGES-1003, ¶232.

Fourth, graphene facilitates fabrication of “electrodes with a high tap density and long-term cycling stability.” LGES-1008, [0148]; LGES-1003, ¶233.

Fifth, this implementation is merely application of known techniques (graphene in an anode active material composition) to a known structure (the Lee-

Wepasnick composition) to yield predictable results (an anode active material composition containing graphene). LGES-1003, ¶234; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in using graphene as the conducting agent. LGES-1003, ¶¶235-237.

First, Lee confirms that “[t]he conducting agent may be any conducting agent commonly used in lithium batteries,” and graphene is one such conducting agent. LGES-1006, [0057]; LGES-1003, ¶236.

Second, the composition of Zhamu’s anode active material particulates is generally similar to that of the Lee-Wepasnick anode active material composition. *See* LGES-1006, [0040], [0043]; LGES-1008, [0041]-[0044], [0071]; LGES-1003, ¶237.

4. Analysis

(i) Claim 3

In the combination, the “conducting agent” is implemented as “a single or a plurality of graphene sheets,” *e.g.*, the composition includes **graphene**. LGES-1006, [0057]; LGES-1008, [0039]; *see* Abstract, [0002], [0040], [0050]; LGES-1003, ¶238.

(ii) Claim 4

In the combination, Lee describes a composition in which “the conducting agent and the binder were 55% (50% of Si and 5% of carbon nanotubes, by

weight), 30%, and 15%, respectively, by weight,” *e.g.*, the weight ratio of conducting agent (graphene; *see* [3]) to carbon nanotube is 30:5, *i.e.*, **6:1**. LGES-1006, [0085]; *see* [0057], [0064], [0091]; LGES-1003, ¶¶239-240. This weight ratio (**6:1**) falls within the recited range of weight ratios and thus, in the combination, renders obvious the recited range of weight ratios. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782. LGES-1003, ¶239.

V. PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The *Fintiv* Factors Favor Institution—§314(a)

The Board should not discretionarily deny based on the *Fintiv* factors.

Factor 1 is neutral; neither party has requested a stay in co-pending litigation.

Factor 2 is neutral based on an expected Final Written Decision date in December 2025, which is within a few weeks of the likely trial date. In particular, the median time-to-trial date for EDTX is currently 21.4 months, which would suggest a likely trial date in November 2025. *See* [fcms_na_distprofile1231.2023_0.pdf \(uscourts.gov\)](#), 35. Moreover, the Court set the trial date for December 2025. *See generally* LGES-1053.

Factor 3 favors institution; Petitioner has diligently filed this Petition months ahead of the one-year time bar, while the EDTX litigation is still in its early stages and investment minimal.

Factor 4 favors institution; if the Board institutes trial, Petitioner stipulates not to seek resolution in the district court of the same grounds presented in this Petition.

Factor 5 is neutral; parties in the parallel litigation are the same.

Factor 6 favors institution; the Petition presents a compelling case of invalidity.

B. The *Advanced Bionics* Test Favors Institution—§ 325(d)

This Petition presents new prior art and arguments against the Challenged Claims for which the file history contains no indication that the Office ever previously considered in connection with the '909 Patent. Indeed, none of Ohata, Kavan, Lee, Wepasnick, or Zhamu—the only references applied in this Petition against the Challenged Claims—were previously cited or applied in a rejection during prosecution of the '909 Patent.

VI. PAYMENT OF FEES – 37 C.F.R. § 42.103

Petitioner authorizes the Patent and Trademark Office to charge Deposit Account No. 06-1050 for the fee set in 37 C.F.R. § 42.15(a) for this Petition and

further authorizes payment for any additional fees to be charged to this Deposit Account.

VII. CONCLUSION

The Challenged Claims are unpatentable. Petitioner authorizes charge of fees to Deposit Account 06-1050.

VIII. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

Petitioner, LG Energy Solution, Ltd., is the real party-in-interest.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

Petitioner is not aware of any disclaimers, reexamination certificates or petitions for *inter partes* review for the '909 Patent. The '909 Patent is the subject of a number of civil actions including: *Molecular Rebar Design, LLC et al v. LG Energy Solution, Ltd.*, 2-24-cv-00107 (EDTX) filed Feb. 16, 2024 (Pending) and *Molecular Rebar Design, LLC et al v. Samsung Electronics Co., Ltd. et al*, 2-24-cv-00108 (EDTX) filed Feb. 16, 2024 (Pending).

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at IPR18768-0210IP4@fr.com
(referencing No. 18768-0210IP4 and cc'ing PTABInbound@fr.com).

Respectfully submitted,

Dated: June 7, 2024

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(Control No. IPR2024-01006)

Counsel For Petitioner

CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,954 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: June 7, 2024

/W. Karl Renner/

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on June 7, 2024, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided by Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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